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DIVISION OF WATERSHED MANAGEMENT RESEARCH

Semiannual Report

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U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

April - September 1956

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SEMIANNUAL REPORT
Division of Watershed Management Research
April - September
1956

Washington Office

Two major activities during the reporting period have occupied the energies of the Washington Division Office. First, was participation in the preparation of material for the Department Committee on Research Evaluation. This monumental task of critically reviewing the entire research program of the Department has been completed and the report has been submitted to the Chief, FS, and the Administrators of ARS and AMS. It is expected that the report will be reproduced shortly for distribution.

The second big job--not yet completed--has been the development of the 10-year research program. This has involved digesting the needs and proposals submitted by the Stations, developing a coordinated program, and tailoring it to a size that can be reasonably expected to be developed in a 10-year period.

It is encouraging to see some discussion in the present report. Your attention is called to pages 8, 9, and 10 of the California Station section. This is important as it presents some concepts that have a bearing on our work at a number of locations.

Apparently the Northeastern's Mountain State Center has a problem (see page 5 of their section). Anyone having an answer should advise our West Virginia brethren--also include it in your next semiannual report for the benefit of all.

All hands should carefully study Hoover's contribution, in the Rocky Mountain section, about the need for ideas as to automatic measurement of sediment in flashy or intermittent streams. Solution to this problem would be of great value to our program. What is needed is for someone to come up with an entirely new approach to the problem. Those who have been thinking about this problem tend to channelize their thoughts too much along conventional lines. The solution could quite possibly come from someone who never even thought about sediment measurement before.

Let's have more comments and discussion in the next report.

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SEMIANNUAL REPORT

Division of Watershed Management Research
California Forest and Range Experiment Station

April 1956 through September 1956

GENERAL

The California State Board of Forestry approved continued financial aid to the San Dimas Experimental Forest through fiscal year 1957; and the State Legislature, through the Department of Water Resources, made a substantial appropriation for the new snow research project.

The new snow research started July 1. Former Division Chief, E. A. Colman, had supplied the impetus for getting the project under way. His "Operation Wet Blanket" caught attention, and his logical analysis of the proposal held it. Some 25 specialists and consultants have contributed substantially to the first seven phases of the work.

The Edward A. Colman Memorial Fund was established soon after "Ted's" death in March 1956. Purpose of the fund is to provide a fellowship for graduate study to help train workers in the field of watershed management research. More than $3,000 have been received from 116 individuals and groups. A committee of Dr. Colman's colleagues is planning for the fund's permanent administration. An additional $70,000 must be raised to provide a living memorial--an annual fellowship attractive to outstanding students.

PERSONNEL

Mrs. Lucille Richards, Forester, joined the Berkeley snow research staff on May 20.

Arnold Court joined the Berkeley snow research staff June 18. Arnold will coordinate the meteorological, hydrological and statistical analyses, and is special advisor to the station on meteorological problems. He will spend half time teaching meteorology and climatology at the University.

Charles Kraebel retired June 30 after 29 years as Division Chief and Subject Matter Specialist in Watershed Management Research. Retirement did not mean inactivity, however. Charles, now a Specialist in Forestry, is a member of the University of California advisory team to the College of Agriculture, National Taiwan University, Taipei, Formosa. On October 10 Charles and his family fly west for a year in Formosa.

Kenneth R. Knoerr, Forester, reported to the Central Sierra Snow Laboratory at Donner Pass July 1, and has been assigned meteorology and snow physics problems.

Henry Hellmers transferred to the Division of Forest Management Research on July 1. He will remain in southern California as a member of the San Dimas Research Center, working at Cal-Tech on forest regeneration problems.

Walt Hopkins took up his new duties as Division Chief on August 20. A pre-war watershed management man at the Rocky Mountain Station, Walt was most recently in charge of the East Gulf Coast Research Center, Southern Station.

Ethel Davidson, division secretary, transferred August 27 to the Federal National Mortgage Association, Housing and Home Finance Agency in Los Angeles.

Paul Zinke, Soil Scientist, resigned September 1 to become Assistant Professor in the School of Forestry, University of California at Berkeley. He will fill the Forest Influences chair which has been vacant since the retirement of Joseph Kittredge.

Shirley M. Kelly, Clerk-Typist at the San Dimas Work Center, resigned September 7 to devote full time to her family.

Peter J. Wyckoff, Forester, transferred to snow research from the fire division on September 30.

Student and special assistants in the snow research project included Kenneth Jackman, photographer; George Blitz, botanist; Bob Wagle, instrument specialist; and Carl Johannessen, ecologist.

PUBLICATIONS

Manuscripts Published

"Forest-Cover Effects on Snowpack Accumulation and Melt, Central Sierra Snow Laboratory" by H. W. Anderson, Trans. Amer. Geophys. Union 37(3): 307-12, June 1956.

Manuscripts Accepted for Publication

"Uses of Soil-Vegetation Survey Information in Watershed Management," by P. B. Rowe and E. A. Colman has been accepted for publication in Soil Science Society of America Proceedings 21(2). This article was abstracted in the semi-annual report for April-September 1955.

New Manuscripts

"Relating Sediment Yield to Watershed Variables" by H. W. Anderson, submitted to the American Geophysical Union for publication as part of a Symposium on Land Erosion and Sedimentation. The manuscript discusses seven studies that used multiple regression to relate sediment yield to watershed and storm variables, taking into consideration methods of selecting

watersheds, data, variables, and functions; and the effects of neglected variables, errors in variables and exclusion of nonsignificant variables.

Miscellaneous Paper No. 11, "A Guide to the San Dimas Experimental Forest," has been revised and re-run. The text was brought up to date and the bibliography was improved by chronological listing by subject. Authors are Sinclair, Hamilton, and Waite.

"Growth of Native and Exotic Plants under Climatic Conditions of the San Gabriel Mountains, California," by H. Hellmers and W. C. Ashby.

A prospectus for a paper titled "Rainfall-Elevation Patterns in the San Gabriel Mountains" was prepared by Hamilton.

CURRENT RESEARCH

Snow Studies

The snow research project is well under way. Work has begun on seven phases of the study as follows:

Phase 1. Inventory of Sierra Hydrologic Characteristics. The distribution of forest stands, openings, and other land types in the Sierra Nevada must be known according to elevation zones, steepness of slope, aspect, and geologic type. The information is being obtained from approximately 1,000 sample plots studied from maps and air photos. The topographic characteristics have been tallied, and the forest and land use characteristics are being determined.

Phase 2. Selecting and Testing Central Sierra Experimental Watersheds. A preliminary selection of seven small watersheds, 200 to 700 acres in size, has been made in the Onion Creek basin, south of the Laboratory headquarters near Soda Springs. Maximum stage recorders will be installed and records will be taken weekly for about nine months. Then, four or five of the watersheds will be selected for continued study and permanent gaging stations will be installed.

Phase 3. Stream Gaging and Sediment Measurement at Teakettle Experimental Watersheds. The pre-treatment measurements of discharges and sediment of five small watersheds northeast of Fresno in the Kings River drainage will be renewed. The reservoirs have been cleaned of 18 years' accumulation of debris. Stevens Type A35 stage recorders have been installed and arrangements have been made for periodic servicing of the gages by the Pacific Gas and Electric Company. Sediment will be measured annually.

Phase 4. Inventory of Forest Conditions at Central Sierra Snow Laboratory Snow Courses. The study seeks refinement of the characterization of forest stands reported by Anderson in Trans. Amer. Geophys. Union 37(3): 307-12, and refinement of the concepts of hemispherical and eliptical cover measurements used and reported in Snow Invest. Res.

Note 12, published by the Corps of Engineers and U. S. Weather Bureau, June 1953. The study will test how well, with present knowledge, we can predict the effects of forest stands on snow accumulation and melt, and will seek guides as to what basic studies will be likely to increase our knowledge. A detailed inventory of forest cover has been made.

Phase 5. Soil Vegetation Surveys of Central Sierra Laboratory Area and Teakettle Experimental Watersheds. Purpose of the survey is to provide a basic inventory of soil and vegetation sites available for study and treatment in the laboratory areas; to form a basis for applying research results to other areas; and to develop methods of utilizing soil-vegetation inventories in watershed management.

Phase 6. Basic Meteorological and Snow Physics Measurements, Central Sierra Snow Laboratory. The objective is to provide continuous records of time variations in meteorological and snow physics characteristics. Measurements will be made at four stations--two at sites formerly maintained by the Army and Weather Bureau, and two on exposed summits. Meteorological measurements will be made at all stations. They will include wind speed and direction, air temperature, and relative humidity. Radiation and the physical properties of snow will be measured at an opening near the headquarters station.

Phase 7. Study of Wind During Snowfall Hours. The objective is to determine the time and spatial distribution of wind flow as a guide to the selection of sites and design of experiments to determine where snow falls and where re-distribution of snow occurs. Tabulations of hourly wind direction and velocities at selected stations in the Sierra Nevada are under way as an exploratory step in this study.

San Dimas Experimental Forest

Streamflow Calibration Analyses. The standardization analysis of weekly mean streamflow for the Big Dalton watersheds VIII, IX and X has been completed and a detailed outline for an office report prepared.

Streamflow and precipitation (including snow) records for the hydrologic years 1938-39 through 1953-54 have been processed for San Dimas watersheds I, II and III for use in the calibration analysis of streamflow described in March 1956 Semiannual Report. This includes separation of each year into wetting, percolation, and drying periods, and computation of weekly mean daily flows in c.s.m. A soil survey of control watershed III was made to delimit soil classes on the basis of hydrologic characteristics, particularly water storage capacities, for use as controls in the analyses. Field work on the survey was completed and a report is in preparation.

Evapo-Transpiration Studies. Summaries of data from the San Dimas large confined lysimeters show striking differences in the disposition of rainfall under the various types of plant cover and bare soil. Surface runoff was greatest from the bare lysimeter, generally amounting to three times

as much as from the vegetated lysimeters, and soil moisture storage in the bare and grass lysimeters was approximately double that of the lysimeters with brush and tree species. Seepage occurred this year only from the lysimeters covered with grass. Loss of water through evapotranspiration during the last hydrologic year was much less from the bare lysimeter than from any of the lysimeters covered with vegetation.

The different types of vegetation have quite different soil moisture drying curves and these differences can be expressed as constants in a soil moisture depletion equation. The drying curve for Coulter pine cover shows rapid depletion of soil moisture beginning immediately after the last rain of the season and continuing until the soil is nearly at the wilting point. The drying curves for the various brush species fall off slowly for nearly a month after the last rain of the season and then begin a rapid decline until the wilting point is reached. The drying curve for grass cover is similar to the curve for brush except that drying for the tank as a whole stops under grass far above the wilting point. This is due to the shallower depth of root penetration. The curve for the bare lysimeter shows a slow but steady moisture loss beginning immediately after the last rain in the season.

Los Angeles River Watershed

The Station's work in the Los Angeles River watershed has been reduced. Testing of exotic plants under controlled conditions in the Earhart Laboratory at the California Institute of Technology was terminated July 1. Measurements of soil movement on slopes at nine steep, brush-covered sites is being continued.

A progress report concerning the stabilization of critical sediment sources in the Los Angeles River watershed was prepared by Hellmers and Zinke. The following conclusions are based on the results of laboratory and field studies plus observations of field conditions and the results of past work of the project:

Vegetation Studies

1. The mountain soils, especially Lowe granodiorite and anorthosite, are deficient in nitrogen. This deficiency limits the growth of vegetation during seasons of the year when water is available. The growth and density of vegetation can be increased by soil fertilization on areas of sparse brush and on areas planted to reduce soil movement. Soil fertilization, however, does not appear economically justified on areas where rates of soil movement are comparatively low.

2. Even though the canopy of mature vegetation (over 30 years old) is not closed in some areas, the plants have extensive root systems that occupy the entire soil mass. Competition for moisture and soil nutrients from these established plants has made interplanting unsuccessful. If cover improvement is needed in such areas, the native vegetation should

be replaced rather than supplemented with other plants. Interplanting can be successful where pockets of new soil are formed such as those behind channel and slope barriers.

3. Plantings on very steep slopes and areas with active soil movement should be limited to locations that have had the surface and toe of the slope stabilized. Such stabilization will have to be obtained by mechanical means.

4. The invasion of native shrubs into newly stabilized areas can be supplemented by planting to develop a soil cover more rapidly. Leguminous shrubs that will increase soil fertility should be favored. In all, about a dozen species have been found suitable for slopes in Los Angeles River watershed.

Soil Studies

1. Yields of eroded material from different types of slopes ranged from 0.15 to 3.5 tons per acre per year. The largest yields came from a relatively small portion of the watershed. Only 10 per cent of the watershed contains slopes having high sediment production. Soil stabilization work should be localized on the areas producing high sediment yields.

2. Measurements during a three-year period have shown that there is nearly as much surface material moving down the slopes by dry creep in summer as by active washing in winter.

3. A classification system for land forms according to the sediment producing potential of slopes has been made. Slopes are classified as geologically rejuvenated and nonrejuvenated. Rejuvenated slopes are further classified into their component parts. This classification can best be used in conjunction with a vegetation-soil survey. Areas to be stabilized should be mapped according to this classification as a basis for planning the work.

MEETINGS

April 23.--Colman talked at the plant physiology seminar at the California Institute of Technology.

May 2.--Anderson attended the American Geophysical Union meeting in Washington, D. C., and gave a paper on "Relating Sediment Yield to Watershed Variables".

May 9.--Anderson represented the division at the Field Day of the University of California at Hopland, and spoke briefly of watershed management research being done by the Station.

May 21.--Zinke spoke to the Earthworm Department of the Los Angeles County Farm Bureau on watershed management research at the San Dimas Forest.

July 13.--Anderson attended the hearing of the State Senate Committee on Public Lands at Sacramento and spoke on the role of watershed management research in making water and timber a dual crop.

COOPERATION

Pacific Gas & Electric Co.--Anderson discussed with John Bonner, P.G. & E. Chief Engineer, the determination of water losses from reservoir areas before and after installation of the dams. Arrangement for a Soil-Vegetation survey of their reservoir watersheds was made and the company agreed to service our Teakettle gaging station and take meteorological and snow evaporation measurements for us.

Humboldt County Department of Forestry.--Results of the Colman-Gleason study of the Bull Creek Watershed were presented and discussed in an office report, copies of which were sent to Eugene Hofsted, Forester for Humboldt County. The report pointed out ways in which flood damage could have been reduced if greater care had been used in logging the watershed. It also suggested additional work needed to get quantitative information on the effects of logging and other land uses in accelerating runoff and erosion in the watershed.

U. S. Forest Service, Region 5.--Gleason accompanied Kenneth E. Bradshaw, now Soils Specialist for Region 5, in an examination of watershed lands tributary to Trinity Dam which is to be built soon by the Bureau of Reclamation to divert water to the Central Valley. Purpose of the examination was to appraise land use conditions and soil erosibility with respect to sedimentation rate of the new reservoir. Logging and road construction practices commonly used were found to constitute a threat of accelerated erosion in the watershed, and the use of improved practices was suggested. Copies of the report will be sent to the Bureau of Reclamation and circulated in-Service.

Arizona Watershed Program.--At the request of Dr. George W. Barr, in charge, Arizona Watershed Program, Rowe visited the Salt River Valley on a study to determine possibilities of increasing water yield from the Verde and Salt River watersheds above Granite Reef Dam near Phoenix.

City of Glendora.--Craig McMicken, City Manager, and Duffy Atkinson, Public Works Director, met with Sinclair, Rowe and District Ranger Lewis to obtain information on the possible effects of the recent Little Dalton Canyon burn on storm discharge and erosion rates, and to discuss control measures that might be taken.

Dr. Ray Specht.--Dr. Specht of the University of Adelaide, Adelaide, Australia, spent several weeks on and near the San Dimas Experimental Forest studying soil properties which may be related to length of time since an area was burned.

Flood Prevention Survey Team of Southern California. Marvin J. Rosa, Region 4; J. H. Dorroh, SCS; and Frank M. Henry, Region 5, hydrologists,

consulted with Rowe and obtained data on most probable peak discharge and erosion rates for the San Bernardino National Forest watersheds which were burned over by the McKinley fire of September 21 to 25.

Public Utilities Commission, State of California, Hydraulic Division.--R. H. Knagg, engineer, discussed with Rowe possibilities of reducing evaporative loss from the spring and riparian areas of Boneyard Canyon as a means of increasing the water supply for Desert Springs.

VISITORS

During the past six months there have been about 175 visitors to the San Dimas Experimental Forest. Included were classes from Mt. San Antonio College, Pomona College, Los Angeles State College and the University of California at Riverside and Berkeley. Municipal water company and citizens' groups were also represented. Foreign visitors came from India, Japan, Formosa, Chile, Israel and Tunisia.

COMMENTS

Comments by R. A. Merriam on "Effect on Streamflow of Cutting a Forest Understory" by Johnson and Kovner, Forest Science, June 1956

The study presented in this paper is interesting and presents information about a subject of which little is known. The basic information is good. I believe, however, there are some questionable statements and conclusions in the article.

I take particular exception to the paragraph which starts at the bottom of page 85 and continues on to page 86. "The analysis of covariance ...showed that the variances are homogeneous, and regression coefficients are not significantly different at the 1-per cent level. The regression lines for the two periods will, therefore, be considered parallel...."

The analysis of covariance does not show that variances are homogeneous. The best any analysis can do is show that the variances are not heterogeneous unless the unusual occurrence at a selected level of probability has taken place.

I find nothing in Snedecor's discussion of covariance which would lead to the statement that the regression lines for the two periods should be considered parallel because a significant difference is not shown. If significance at the 1-per cent level, however, is required for differences between the two regression coefficients and is not reached, a properly calculated average of the two regression coefficients becomes a better estimate than either coefficient. If this situation exists, shouldn't this average be used in the later analyses rather than the pre-treatment regression? It appears that the rest of the analyses in the paper depends upon the acceptance of significance at the 5-per cent level rather than rejection because of failure to reach the 1-per cent level.

I also take exception to the handling of the data in the growing season analysis. The deletion of the first post-treatment year's data from this analysis is justified by the authors because of the extrapolation required in estimating the streamflow. Is it coincidence that when this first year's data is dropped the precipitation becomes nonsignificant in the resulting analysis? I question whether this is any more justified than would be the deletion of the first post-treatment year's data for the annual amounts. In the growing season the extrapolation is to 35 inches in an equation derived from data between 12 and 23 inches. In the annual amounts, the extrapolation is to 75 inches in an equation derived from data between 42 and 61 inches. Other inconsistencies in the use of statistics seem an attempt to mask questionable or hazy results under an aura of statistical respectability.

In conclusion it seems that the authors were confronted with the unfortunate circumstances of extremely high rainfall the first year after treatment and a high chance correlation between precipitation and the number of years after treatment. From an examination of the data available in the published article, the precipitation during the first post-treatment year was unusual in other respects than its total quantity. The precipitation minus runoff is by far the lowest on record, and a larger per cent of the total precipitation appeared as runoff than in any other year of the study. Also, a higher per cent of the precipitation fell during the growing season. Some mention should have been made of these unusual circumstances to permit the reader to form a more accurate picture of the results. It is also unfortunate that the data for the year of maximum were not included in the study. In any case, the year of this extreme should have been stated for the benefit of the reader in estimating possible effects of antecedent precipitation.

Too often, perhaps, the desire to wait for one more year's data is only an excuse to put off an unwanted job. In this instance, however, waiting for additional data could have been more than justified by reducing the chance correlation between time and precipitation. It would also have permitted a better analysis of the time trend. This might be expected to follow a logarithmic rather than a straight line trend, as has been indicated by the analysis of Watershed 13 at Coweeta reported in the Division Semiannual Report, April-September 1955.

Further Comments on Above by Arnold Court

Careful examination of the entire concept of linear regression is required in analyses such as that by Johnson & Kovner, discussed by Merriam. Distinction must be made between the regression line that provides the best fit to a sample of observation pairs (x_i, y_i), and the line that is the best estimate of the true relation between the two random variables, X and Y.

As far as the sample alone is concerned, if the relation between the two variables is linear, the set of observation pairs is best fitted by the classic linear regression

$$E(y|x) = a + b\,x\ .$$

Here $E(y|x)$ is the "expected value" of y corresponding to a particular value of x, and a is the "y-intercept" of the regression line while b is its slope. When a and b are computed by the usual least squares formulas, the sum of the squares of the distances from the observed points (x_j, y_j) to the line is less than the corresponding sum of squared distances to any other straight line.

This, however, is merely the best fit to the available data, and may not be the best estimate of the true regression of Y on X. Additional information may be available to indicate the nature of the regression--in particular concerning the y-intercept a. In many cases, such as the one under discussion, physical reasoning can provide "boundary conditions" for the regression function, both as to its form (linear in this case) and its parameters. Specifically, the reasoning indicates that the function relating the two populations should pass through the origin, so that $a = 0$.

The regression used by Johnson and Kovner, $y = 0.804 + 0.906\ x$, provides the best least squares fit to the seven points available, but not the best estimate of the regression of Y on X for all possible values. The average annual flows of Watersheds X and Y are 52.16 and 48.06 inches, respectively. Thus Y would be expected to have no flow when X, which normally has a little more than Y, has none. Yet the sample regression, extrapolated to zero, indicates a flow of 0.804 inches in Y when X has none.

A more realistic regression for the case in question, therefore, would be simply

$$E(y|x) = b\ x.$$

Then the investigation would revolve around the various estimates of b--for the control and treatment years separately and combined.

Physically, this model implies that treatment may alter the ratio Y/X, rather than the difference Y - X. For the annual flows of adjacent small watersheds, presumably experiencing similar weather regimes, such an assumption may be preferable.

SEMIANNUAL REPORT OF WATERSHED MANAGEMENT RESEARCH

CENTRAL STATES FOREST EXPERIMENT STATION

April - September 30, 1956

General

During the past 6 month period a Division of Watershed Management was established at this Station. E. A. Johnson, Research Center Leader of the Coweeta Hydrologic Laboratory was appointed as the new Division Chief.

Water is a popular subject in Central States territory. Water use is high, for example, Ohio is fourth among all the States in rural water consumption and fifth in total water use. Since 1951 there have been three growing seasons of below normal precipitation which have helped focus attention on the importance of a watershed management research program. Water shortages during recent drought years have stimulated action by some states for providing their citizens with data on the nature and extent of their water resources, major water uses, and water problems facing the state. Two states have publications in this field: VALLEYS OF OPPORTUNITY - THE WATERSHED CONSERVATION PLAN FOR OHIO by the Ohio Forestry Association, and ILLINOIS WATER SUPPLY - WATER RESOURCES AND WATER PROBLEMS ENCOUNTERED IN ILLINOIS by the Illinois State Chamber of Commerce.

The Central States Station has watershed management research projects at its Athens, Ohio, and Columbia, Missouri research centers. This new division will assist in starting new projects at other research centers as needed, and will correlate watershed management with other Station research projects.

Athens Research Center

Current Studies

During the spring of 1954 water runoff troughs were installed on plots, 4 feet wide and 20 feet long, to determine the quantity of water runoff and sedimentation under an undisturbed oak forest, clearcut forest land, and abandoned fields. Carmean reported on some differences in runoff characteristics during the 1954 growing season, in the April - September 1954 Semiannual Report. Plans for the next quarter are to compile and analyze these plot data.

Also in 1954 a study was started to determine differences in soil moisture between clearcut and undisturbed oak stands. Plans for the winter months are to complete the laboratory determinations and start analyzing the data.

Another long-term study started in 1954 deals with relations between oak-site quality and the soil and topographic features of southeastern Ohio. Plans call for including all the species of oak important in Ohio. Black oak was selected as the first species. Carmean has reported on developments in the October 1954 - March 1955, and October 1955 - March 1956 Semiannual Reports. By the end of the current field season over 100 site plots will have been located.

Some preliminary measurements were obtained this past summer for establishing a study on the effect of some vegetal cover types in southeastern Ohio on water available for streamflow. Plans are to complete the study plan around January 1.

Cooperation

The Soil Conservation Service assigned a soil scientist from its Soil Survey staff to examine the black oak soil-site plots established during 1954, 1955, and 1956. The objective of this cooperative undertaking is to correlate oak site quality with soil series as mapped by the Ohio Soil Survey. It is hoped that land productivity for tree growth can be classified in the same way that land productivity is now classified for agricultural crops.

Meetings

W. H. Carmean attended the annual meeting of the Ohio Academy of Science held April 21, 22, at Wittenberg College, Springfield, Ohio. He presented two papers; one on Blackoak soil-site research and the other on water infiltration as related to physical soil conditions and land use in southeastern Ohio.

In August, Carmean attended the annual meeting of the Northeastern Forest Soils group held at Burlington, Vermont. This conference was largely concerned with soil-site research now being conducted in Vermont. Field trips were taken to inspect soil-site plots established in both natural northern hardwood stands and in pine plantations. Site studies in this area are complicated because of uneven-age stand and excessive soil disturbance caused by windthrow.

Columbia Research Center

Ronald Whipkey transferred to the Columbia Research Center on August 2 to help set up a program of research in watershed management in the Missouri Ozarks. This research program in Missouri will be carried on in cooperation with the Department of Forestry, University of Missouri. As a part of this cooperative undertaking, Whipkey will be registered in the Graduate School for part time study with a major in watershed management that will lead towards a Master of Science in Forestry.

H. C. Storey, Director McGinnies, and Johnson met with Dean Westfeld and Professor Peter Fletcher September 13 to discuss watershed management objectives and a research program in Missouri. The period, September 14-16, was spent in the field getting acquainted with watershed management problems in the Missouri Ozarks. Additional conferences and field trips are planned before starting on a long term program of research for the Missouri Ozarks.

SEMIANNUAL REPORT ON WATERSHED MANAGEMENT RESEARCH
Intermountain Forest and Range Experiment Station
April-September, 1956

H. C. Storey arrived at the Station in mid-September for a month's inspection of the WMR activities. This was Herb's first visit to the 300-million acre Station territory. The first three weeks of his visit were devoted to consideration of going and needed research on watershed restoration, maintenance and improvement problems at the Wasatch, Great Basin, Reno and Boise Centers. The last week included a fast tour of the forest and range watershed problem areas in the R-1 portion of the Station territory.

New Personnel

Walter J. Kidd joined the Station in June by way of transfer from the Photo-Interpretation Unit in the Chief's office. Joe was temporarily and briefly assigned to the Wasatch R. C. but in July was retransferred to the Boise R. C., where his family joined him.

Dale J. Pfankuch joined the Station in July. Dale has been assigned to the Wasatch R. C. He was granted the M.S. degree from the University of Minnesota in June.

R. O. Meeuwig has been granted an educational furlough to start work on the Doctorate in Forest Influences at the University of California. While at the Wasatch R. C., "Rich" developed a new A. C. ohmeter for use with the Colman soil moisture fiberglass unit. The new ohmeter is only about one-fourth the size and weight of the earlier models, and Rich thinks he can make one that is even smaller and lighter. Packing the old model up and down the steep slopes of the Wasatch Range no doubt gave impetus to Rich's after-hour efforts toward developing the smaller and lighter meter.

BOISE RESEARCH CENTER

Effect of Certain Haul Road Factors on Sediment Production. Earlier semi-annual reports on the logging disturbance-soil stability study located in the Boise Basin Experimental Forest have discussed the adverse effects of haul road location on sediment production. In the past year an intensive investigation of this problem has been in progress on other sale areas in the ponderosa pine type. Currently, steps are being taken to key out the important roadway factors that affect the movement of sediment into stream channels.

To properly identify these factors, it was necessary to focus attention on erosion that was taking place below logging roads which had been "put to bed" with the standard use of cross-ditches and berm removal or outsloping. These measures were designed to hold road surface washing to a minimum. Generally speaking, they have been satisfactory for this purpose, but have not been adequate for safely disposing of drainage water from roads constructed on steeply sloping terrain. Too often it was noted that storm runoff diverted by the ditches had sufficient eroding power to cut into the long road embankments and to carry the suspended material down the lower side slope for great distances, sometimes for hundreds of feet. In some instances the sediment flow emptied in stream channels; in others, the flow stopped short of reaching the channel, having been retarded or completely trapped by slope obstructions in the "buffer strip."

From numerous observations of the latter type, such factors as road width, road gradient, cross-ditch interval, embankment slope length, retardation factor (derived from the number of major obstructions), and lower side slope were measured and are, at present, being tested in a regression analysis. From this analysis the significant factors will become part of an equation to predict sediment flow distance. This value will then be used as a criterion for determining the minimum width of buffer strip. It is believed that this criterion and others will become useful guides for locating roads safely away from stream channels.

Grass-cover Establishment in the Ponderosa Pine Type. In the fall of 1955 reseeding trials were installed on several miles of logging road subsequent to hauling. The primary purpose of the test was to evaluate four methods of planting. They were: broadcast of seed, broadcast followed by harrowing, broadcast prior to deep scarification with a road patrol, and the latter reversed to provide a fourth treatment. These methods were replicated 16 times on two exposures, providing a total of 128 plots. On 96 of the plots a top dressing of 46-45-0 fertilizer and a covering of chip mulch were applied separately and in combination. The other 32 plots did not receive the extra treatment.

This season's observations indicate that the two scarification treatments show promise as being practical for establishing grass cover on hard-packed road surfaces. Also, there appears to be a response from fertilizer in number of plants and vigor of first-year seedlings on many plots. On the other hand, mulching with slash chips probably will not increase number of plants, although as a temporary ground cover, it will retard soil movement.

In 1957 it is planned to collect quantitative data on number of plants per square foot, percent of ground cover, and weight of foliage production from belt transects in each plot.

Cover Restoration in the Elk Sedge Range. In September a new study was initiated on high elevation range of this type. The study area was part of the Sulphur Creek flood-source area, specifically the upper slopes of Morehead Mountain, where this summer the Boise National Forest has constructed many miles of contour trenches to contain overland flows of any future storms likely to cause a repetition of the Sulphur Creek flood of July 23, 1955.

The research effort consists of two parts. One is to check on the efficacy of applying fertilizer of various strengths to the newly seeded contour trenches. Trenches were seeded with a mixture of six promising grasses at a rate of 20 pounds per acre. Fertilizer was applied on various intervals along the trenches at the following strengths: 46-0-0, 0-45-0, 46-45-0, and 92-90-0. Effects of the fertilizer on the production of ground cover will be checked during the next few years.

The second part of the study is to evaluate the rate of recovery on the strips of native range between contour trenches where grazing has been eliminated. Eight plots, testing four methods of treatment, were installed. Two plots were left to natural recovery, two plots were fertilized with the 46-45-0 mixture, two plots with the standard seed mix at the same rate as the trenches, and two plots were seeded and fertilized. Permanent line transects were established on each plot to measure percent of ground cover and species composition.

Data from the transects measured prior to treatment show that the original ground cover ranges from 18 to 42 percent, indicating a very depleted watershed condition. Repeat measurements on the staked transects are scheduled for 1958.

RENO RESEARCH CENTER

Research effort on the flood control problem on the east slope of the Sierra Nevada mountains is scheduled to begin in November. Harold F. Haupt will head up the WMR phases, with headquarters in Reno, via transfer from Boise. Harold reports a contractor has started work on his home in Reno but office space is still to be located. He will be joined by a range man later in the winter.

GREAT BASIN RESEARCH CENTER

Following H. K. Orr's transfer to the Black Hills R. C., the WMR work at the Great Basin has been handled by Bob Thompson and Gene Stephens, both of whom are holdover field assistants from the previous year.

Manti Reseeding Evaluation Study. Orr completed a Station Research Paper covering the results of infiltrometer and plant cover measurements taken on several reseeded and untreated subalpine-herbaceous range plots three years after the study area was closed to grazing and then plowed and seeded. As previously reported, the three year time lapse was sufficient to bring about a substantial improvement in forage production but no significant change in runoff, infiltration, or erosion characteristics. Improvement in the latter characteristics are expected as the seeded grass cover becomes thicker.

The range study area was opened to grazing this summer. Grazing exclusion cages were installed on both treated and untreated plots so as to continue the variable of no grazing in the study, for comparison with other plots that will be grazed. Remeasurements are planned for 1958.

Pleasant Creek Watershed Evaluation Study. Area-capacity measurements were obtained on the sediment traps below a battery of gully control plots on part of the Mt. Pleasant Watershed this summer. The gully plots are intended to determine the effects of contour trenching on sites where accelerated erosion has reached the gully stage. The gully plots were installed in 1955 but measurements of the sediment traps were deferred until this year so as to allow for a winter season of settling. The sediment trap capacity data has now been added to the initial progress or establishment report of the evaluation study. Repeat measurements are scheduled for 1958.

Left Fork-Alpine Cattle Pasture Watersheds. A detailed plant cover and soil survey was completed on these 250- to 300-acre watersheds during the summer. This survey was made as a basis for planning snow-drifting studies and studies of the effects of different range species on interception and mantle-moisture storage characteristics, with a view toward applying measures to one of the watersheds for the purpose of improving snowmelt water yields.

During the summer also, the old chute type flumes were remodeled so as to improve the accuracy of streamflow records and to provide for trapping sediment. This was accomplished by installing a 120° weir at the lower end of the old flume and by plugging the upper end to form a debris basin. Whether a cover will have to be added to the installation to avoid or minimize icing remains to be determined during the coming winter and snowmelt season. Observations of normal snowdrifting on the two watersheds are also planned for the coming winter.

WASATCH RESEARCH CENTER

Flood-Source Water Consumption Study. As previously reported, the upstream flood control measures applied in the Parrish Creek basin of the Davis County Experimental Watershed, appears to have reduced snowmelt discharges as well as prevented the recurrence of summer rain mud-rock floods. During the summer a study was initiated to determine effects of flood-source conditions on mantle moisture storage in the headwaters of Parrish Watershed. The study will compare mantle moisture conditions on aspen, brush, and herbaceous sites now in a restored condition with comparable areas on which flood-source conditions will be re-created by removing or drastically depleting the herbaceous, shrubby and low-growing aspen vegetation. The study will be carried out in cooperation with the School of Forestry, Range and Wildlife Management of the Utah State Agricultural College.

Mantle moisture data required for the study will be obtained by a portable Neutron scattering device as well as by gravimetric sampling. The Neutron device is being made available from the USAC. This device has been developed and field tested by Sterling Taylor of the Soils Department of USAC. Like the Neutron moderation unit reported in the July 1956 issue of Soil Science by Von Baval, Underwood and Swanson, the Taylor device registers the concentration of hydrogen ions in the soil, which readings can be directly converted to inches of water. Tests of this device on the study area are planned for this fall. If the tests prove to be successful, the new unit will eliminate the time-consuming job of collecting bulk density samples. Such a unit would be especially useful in soil-moisture studies on rocky soils.

In preparing one of the aspen sites for the above study, approximately 3.84 green weight tons of forage per acre were removed in the process of simulating the original, depleted flood-source cover conditions. This is 10 to 15 times the amount of herbage material produced on depleted flood-source areas.

An article, "Air Movement Under an Aspen Forest and on an Adjacent Opening" by R. B. Marston was published in the July, 1956 issue of the Journal of Forestry.

INLAND EMPIRE RESEARCH CENTER

Northwest Science has accepted an article by A. R. Stage, "Some runoff characteristics of a small forested watershed in northern Idaho." This article is based on 16 years of streamflow records on Benton Creek, a 950-acre watershed within the Priest River Experimental Forest. This record is believed to be the only one available from such a small forested watershed in northern Idaho.

MISSOULA RESEARCH CENTER

Problem Analysis. P. E. Packer completed an office draft analysis of the watershed management research problems in the R-1 portion of the Station territory. This constitutes the first step in formalizing watershed research in that area.

The analysis considers some 90 million acres of forest and range lands which contribute 65 million acre feet of water to the Columbia River. It also considers some 70 million acres of forest and range lands east of the Continental Divide which contribute 17 million acre feet of water to the Missouri River.

The water in these two major drainage basins is a highly valuable resource. Nearly $3 billion have already been invested in water control structures on these two rivers and plans call for an additional investment of some $12 billion in similar structures.

The analysis revealed numerous watershed management problems on which research is needed. Some of these problems involve determination of ways and means of restoring control of runoff and erosion on lands that have been damaged by overgrazing, fire, faulty logging practices, and poor road construction. Others involve finding ways to maintain or improve runoff characteristics by adjustments in forest and range management practices.

High on the list among the latter problems is that of handling western white pine lands in the headwaters of the Columbia River. This highly valuable timber type occurs on steep lands that are subject to deep snows and rapid snowmelts which contribute to major floods. Western white pine management requires a high concentration of logging roads, clear cutting, burning of slash, eradication of ribes for control of blister rust, and planting. These forest management practices mean that at least one-fifth of the western white pine lands will be kept in a clear-cut condition for many years, pending the regrowth of new stands. This poses the problem of how to maintain control of snowmelt discharges on the clear-cut lands.

An equally serious problem has developed on lodgepole pine lands in the headwaters of the Missouri River. There, watershed management research is needed to determine how to increase summer yields of water without increasing snowmelt floods. This will be a difficult problem because it involves lands that require clearcutting, burning, and an intensive logging road system for forest management purposes.

One of the next phases of the research program will be to locate suitable experimental watersheds in the western white pine and lodgepole pine types.

NORTHEASTERN FOREST EXPERIMENT STATION

Division of Watershed Management Research

Semi-annual Report October 1956

GENERAL

Progress was made in several different directions during the past six months - read in that what you will - not including, however, loss of Sid Weitzman to Lake States. Sid, we miss you.

Much of the work at Kingston and Mountain State was directed towards calibration of the watersheds. Hal Wilm gave us a hand in an all-day session at Syracuse attended by Weitzman, Reinhart, Reigner, and Lull.

A second meeting for all Station watershed researchers was held at Hubbard Brook in late August. Watershed programs at the three Centers were described and discussed with particular attention to Trimble's just-finished problem analysis for Hubbard Brook. It was strictly a shop-talk session and everyone was heard. Ed Johnson from CS and Lou Metz SE sat in and came up with some good ideas.

Lull ran out of travel money in April: accordingly, all but two of the manuscripts which had accumulated in his basket have moved to our Editor's basket.

KINGSTON RESEARCH CENTER

Problem analysis

At long last, a problem analysis for watershed management research in the Kingston Research Center area is nearly complete. The analysis will be published as a Station Paper after being reviewed by a number of interested agencies.

In preparation of this report, Reigner travelled to Ithaca, N. Y. to see Earl Stone, Professor of Forest Soils at Cornell and George Free, who is in charge of ARS studies in soils and water at the University. Both men are in close contact with the problem of the poorly drained soils in the Northern Dairy Region--the so-called "Volusia Soils". Our ideas on this problem underwent considerable change after discussions with Stone and Free.

Reigner also spent most of a day in Harrisburg with F. G. Loughry, State Soil Scientist, working up a soils map based on latest information available. A soils map of the Northeast, including Pennsylvania is due for publication by the SCS at some future date.

Weir Maintenance

Although streamflow remained rather high during this cool wet summer, we managed to find a period of flow low enough to drain the weir pool at the Pocono Experimental Forest. In addition to cleaning the pool, we wished to plug a leak which had developed around one wing wall.

After draining the pool and examining the soil material against the back and side of the wing wall, we discovered it to be coarse gravel rather than some more impervious material. It appears this material was backfilled after the removal of the concrete forms during constructions. Naturally, the water moved easily through the gravel and subsequently washed a passage through the undisturbed clay against which the concrete was poured. After the gravel was removed, a large hole was found around the side of the wing wall. This hole, and the void left by the removal of the gravel was filled with concrete. So far, the leak is plugged.

A lesson may be learned from our troubles. A void left by the removal of forms should certainly be filled with impervious material. Concrete is best and not expensive--particularly at the time of construction.

A similar job is needed at the Dilldown weir, but flow has not depleted enough this year to drain the pool.

Watershed Calibration

Reigner has continued to spend most of his time delving deeper and deeper (maybe too deep) into the intricacies of the factors affecting the water cycle. A great mass of information is available and the combinations, weights, and interactions are almost innumerable.

In order to estimate runoff during a period such as a season or year, storage values at the beginning and end of the period are necessary. These values must be estimated, too, from factors which will not be affected by treatment (precipitation and other climatic factors). During the past 6 months, methods were developed to estimate groundwater storage and total storage (groundwater plus soil moisture).

Results are tentative and have not been evaluated. However, as there has been some interest in these analyses, we can give you some highlights.

We have found that total storage (groundwater + soil moisture) at the beginning of a month is highly related to runoff during the month. Temperature enters into the relationship, of course. Mean temperature for the month taken to the 4th power is highly correlated; a better parameter is the mean temperature over 40°. Here, all values under 41° are given a value of zero. The square of the latter variable is still more highly correlated. Unweighted precipitation for the month is well related, with an exponential value indicated.

Soil moisture content at the end of the month is negatively correlated with monthly runoff. The analysis of this factor was most interesting, being complicated by the two upper limits in soil moisture--saturation and field capacity. Obviously, soil moisture cannot increase above saturation no matter how much it rains. And, just as obviously, most observations will be at field capacity or below. We found that the effect of antecedent precipitation decreases to about the 28th day prior to the point of measurement, at which time its effect is zero. In order to weight the precipitation value properly, a curvilinear weighting system was applied, with the most recent rainfall being given an exponentially greater weight than earlier rainfall.

The temperature variable is also involved. Testing the exponential values of mean temperature for the previous month, we ran up to about the 9th power, at which time we discovered the low temperature values had no effect on soil moisture. Only temperatures over 60° had any effect on reducing soil moisture. A linear expression of temperature was devised with 61° given a value of 1, 62° given a value of 2, and so on, with all values under 61° called zero. It was much better related than the exponential forms of temperature. Next, average maximum temperatures were tested against mean temperatures; the differences were not great, but maximum temperature over 67° gave the greatest reduction in mean square.

The upper soil moisture limits also limit the amount of rainfall affecting soil moisture. For our conditions, we found this limit to be about 2 inches. Any rainfall over 2.0 inches per 28 days (on a weighted basis) would satisfy retention storage and percolate into groundwater--with an important exception--when water use is high. An interaction of the precipitation and temperature variables satisfies this condition.

The equation may be stated: Soil moisture content at the end of the month = a + b_1 Weighted Precip. up to 2.1 inches - b_2 Average Maximum Temperature over 67° + b_3 Weighted Precip. x Ave. Max. Temp. over 67°. This equation does not estimate soil moisture above field capacity --an infrequent condition--and has an accuracy to 0.28 inches of soil moisture storage in 24 inches of soil. (For this depth, field capacity is 6.95 inches and lowest moisture content reached 3.80 inches). We feel sure that these estimates could be improved, but only by means of other and more complicated variables and interactions.

Art Eschner has been carrying along an analysis of peak flow determinations in the little amount of spare time he has. Using increase in flow as the dependent variable, the best correlations so far were obtained from the square of storm precipitation and an interaction between P^2 and the flow at the beginning of the peak.

Late in April, Reigner joined Howard Lull, Sid Weitzman, and Ken Reinhart in a trip to Syracuse. There we went over all of this calibration business with Hal Wilm. As the Fernow calibration methods are based on a control watershed instead of a single watershed, the discussions were quite varied and most informative. Dr. Wilm gave us a number of worthwhile suggestions including the use of a covariance analysis to check the independence of the values from year to year.

Miscellaneous

Some of the earliest watershed experiments in the Northeast were conducted in the early 40's by the Soil Conservation Service on the Arnot Forest, near Ithaca, N. Y. Reigner visited these watersheds in company with Stone and Free during his trip to Cornell. The primary object of the studies was to determine differences in erosion between forested watersheds and idle land watersheds. As the idle lands had a complete cover of weeds, grasses, and brush, there was no erosion from any of the watersheds.

Although there may have been some confounding of results due to soil differences, an interesting comparison of runoff pattern was developed from these watersheds. On an annual basis, there was no difference in yield between the two types of land use. But there were considerable differences in seasonal yields; during the period June-September, the idle land yielded over twice as much runoff as the forested watersheds.

Also while at Cornell, Reigner met Dr. E. R. Lemon, Soil Physicist for ARS, who had recently come to Cornell from Texas. He described some of the evapo-transpiration studies going on at Texas, A & M. Their work using net radiation data and the heat budget approach is most interesting. We plan to visit Dr. Lemon again to discuss possible applications to our work.

Eschner attended the Northeastern Forest Soils Conference at Burlington, Vermont, early in August.

Later in August, Reigner and Eschner joined the other watershed management personnel in a three-day meeting at Hubbard Brook, New Hampshire. Mostly, we discussed and looked over the Hubbard Brook program which is getting under way nicely. But we also described and discussed the watershed management programs of the Kingston and Mountain State Centers. The weather and accommodations were fine, the discussions were learned, but the hills were just as steep as in West Virginia.

The annual INCODEL meeting came along late in September with Reigner and Eschner attending. One of the most interesting papers was the report of the Delaware River Master who is in charge of releases from the recently completed New York City reservoirs in the upper Delaware River drainage. On one day this past August, 76 percent of the flow of

the Delaware River at Port Jervis, N. Y. was derived from the two reservoirs now completed. After the Cannonsville Reservoir is finished, the contribution to supplementing low flows will be considerably greater.

The last week in May and the first in June, Eschner spent in West Virginia on a training detail. When he reached there the watersheds of the Fernow were really shedding water--causing quite a flurry of activity. The pitch of the activity did not appear to lessen during his stay.

MOUNTAIN STATE RESEARCH CENTER

Soil-Moisture Study

A soil-moisture study got underway about on schedule--thanks to added assistance from Don Lester of Upper Darby and Art Eschner of Kingston. The purpose of the study is to determine changes in soil moisture created by different cutting practices.

It was pleasant to find that the King tube works quite well despite the stoniness of our soils. This eliminates necessity for digging pits to collect samples.

A wet spring and frequent summer rainfall have limited the range of soil moisture measured.

Perhaps the most serious problem is how to determine the stone content of our samples. In sieving out stones, how much force should be used to break up the material? In other words, where is the dividing line between soft stone and hard soil? Consistency in results may be hard to obtain. We are open to suggestions.

Watershed Calibration

An analysis on our original 5 wooded watersheds to determine adequacy of the calibration period has taken considerable time. In April, Lull, Weitzman, Bickford and Reinhart discussed the problem with Hal Wilm at Syracuse. This discussion led to a clearer understanding of our objectives and ways of attaining them.

The analysis indicates that the 5-year results are much better to work with than the 4-year results previously analyzed. The data look good; annual and monthly flows and peak flows of the 5 watersheds are closely correlated and it is possible to predict flow of one from that of another with a small error of estimate. A first try has been made on analysis of low flows using number of days in each year when flow was below 0.050 c.s.m. This amount of flow was chosen because each watershed in each year had at least a few days when flow fell below this value. Results of this analysis are encouraging but efforts will be made to find a better way of approaching the problem of low flows.

Higher than average rainfall for the period--including several good-sized storms--resulted in opportunities for collecting water quality samples.

New weirs

Streamflow records will begin November 1 at weirs 6 and 7 whose cutoff walls were poured last fall.

Cutoff walls for weirs 7 and 8 - for the pasture rehabilitation study - were poured in June.

Tilted gages

Our precipitation gages on the Fernow were installed vertically and we have, of course, been concerned over whether or not we were getting a proper catch. Therefore at 4 sites, gages tilted with the slope were installed and their catches compared with catches from the vertical gages. Over a 9-month period, catches of the 4 tilted gages were 99.8, 97.5, 99.7, and 99.5 percent of the catches from their vertical counterparts. Catches for individual months and individual storms were very close for the two types of gages. We feel that we can go ahead and rely on catches from our vertical gages on our gaged watersheds. However, at one site outside of our gaged watersheds, the tilted gage caught 5 percent more than the vertical. We will want to study that situation further and determine what factors were responsible.

Personnel

Sid Weitzman left the fair hills of West Virginia for the blizzards and icy winds of Minnesota. He'll head up the watershed management research at the Lake States Experiment Station. His first major project - to find some cheap chemical to add to all the water up there to give it the taste and wallop of Bullett County corn.

Real big news was Carl Barr's Superior Service Award which he received in Washington, D. C. on June 5. Carl really deserved this award for helping to make the research program on the Fernow click and for doing such a good job in getting the results of our experiments across to visitors and the general public. Soon after he received the award, he was back on the job working as hard as ever. We wonder if the Department awards Oak Leaf Clusters.

Emmanuel Van Nierop, who received his Master's degree from Syracuse in June, spent the summer working in the soil-moisture study. His visa expired and he returned to Canada September 7.

John Phillips, Soils Scientist, arrived on the job July 2 straight from the campus of the University of Wisconsin.

Meetings

4/19-20 - Weitzman and Reinhart visited New York State College of Forestry to discuss watershed calibration with Lull and Wilm.

8/26-30/56 - Reinhart, Phillips and Fridley attended a watershed management conference at the Hubbard Brook Experimental Forest in New Hampshire.

9/20/56 - Reinhart and Phillips attended the W. Va. Chapter meeting of the S.A.F. at Camp Pocahontas, W. Va.

9/21/56 - Reinhart and Phillips attended the W. Va. Chapter meeting of the Soil Conservation Society of America at Jackson Mills, W. Va.

WHITE PINE-HARDWOOD RESEARCH CENTER

General

It was a long time coming, but spring finally did arrive in these parts. We still had snow on the higher north slopes of the watershed in the latter half of May. As it was, the trees were beginning to leaf out on some parts while we still had snow on others. Fortunately for our contour map-making project, the Navy was able to fly the area and get the necessary pictures in the few days time between the snow and the leaves.

A field survey crew from the Alexandria, Virginia Photogrammetric Field Unit (who is making our map) was here for a couple weeks doing ground control for the mapping job. Sartz pinch-hitted for one of the men who had to return home unexpectedly. An interesting sidelight of this job was that, while occupying the peak of Mount Osceola, the party recovered one of the original U. S. Coast and Geodetic Survey triangulation stations established in 1875, and since lost.

In its first cleaning--after 8 months of operation--the stilling basin of the weir yielded plenty of leaves, twigs and sticks, and one dead frog, but a negligible amount of sediment. The debris basin at the head of the stilling basin, however, held about nine-tenths of a cubic yard of sand and gravel. Cleaned again after a very heavy rain in mid-summer, the basin yielded nearly 2/3 as much coarse material again. It appears that most of the debris collected so far resulted from stream channel disturbance just above the weir that occurred during construction. At present the channel appears to have stabilized again. We're sold on debris-collecting structures above stilling basins in this area of coarse-textured soils.

Skidroad revegetation

A recent expansion has been made of the logging road seeding project at Bartlett, a joint timber management-watershed management project. Now under study for possibilities of seeding down logging roads and trails for erosion control and game food are the following--with and without lime and fertilizer:

1. Barn chaff
2. Orchard grass
3. Rye
4. Oats, timothy, and red top (equal proportions by weight)
5. Red fescue (44%), Kentucky blue grass (20%), red top (20%), domestic rye grass (12%), White Dutch clover (4%)
6. Creeping red fescue (70%), birds foot trefoil (30%)
7. Tall fescue (70%), birds foot trefoil (30%)

Our skidroad revegetation experiment has now encompassed two growing seasons. Preliminary results from this work indicate that several grasses appear to offer excellent protection against erosion on logging roads. While the results are by no means conclusive at this date, we feel that the following grasses can be seeded to good advantage:

Red top
Creeping red fescue
Tall fescue
Orchard grass
Barn chaff

In the White Mountain area, it is necessary to use at least 400 pounds of fertilizer per mile of skidroad to obtain good growth. A 10-10-10 fertilizer is recommended. Tentatively, we also recommend that about one ton of lime--preferably dolomitic lime--be used per mile of road.

Woodland field day

This field day, sponsored by the Extension Service, was held at the Belknap Recreation Area near Laconia in April. This was a public demonstration of good forestry practices. The watershed research unit helped with a demonstration of logging and skidroad layout and maintenance. The affair was well attended and apparently was a great success.

Trimble is cooperating with Extension Service foresters in preparing a leaflet on logging and skidroad practices for New Hampshire.

Show-me Trips

The watershed staff conducted its first full-scale show-me trip of the Hubbard Brook Experimental Forest in June. Three groups (40 altogether) of the Conservation Camp, an annual one-week workshop sponsored by the Society for the Protection of New Hampshire Forests, braved our temporary road and steep climb to look over the weir and weather station installations. In addition, they looked at soil pits and discussed moisture relationships of forest soils. It was an interested and enthusiastic group and we enjoyed having them. (The fact that quite a few were female, young and pretty had nothing whatsoever to do with this). (Humph!)

Professor Harold Hocker from the University of New Hampshire brought a group of forestry students to the Hubbard Brook Experimental Forest for a show-me trip to acquaint them with forest watershed management problems in this area. Nine company foresters for the Draper Corporation visited the Hubbard Brook Experimental Forest in September.

Meetings

Pierce attended the annual meeting of the Northeastern Forest Soils Group in Burlington, Vermont in August.

Trimble attended the summer meeting of the New England Section of the Society of American Foresters in Orono, Maine during the first part of September.

Sartz and Pierce attended a 3-day photographic school given by Charlie Lockard at Bartlett in September.

A highlight of the summer season was the watershed management research conference held at Hubbard Brook in August. All of the personnel engaged in watershed management research in the Northeast attended this meeting. In addition, Lou Metz of the Southeastern Station, and Ed Johnson of the Central States Station were guests. This 3-day meeting included both discussion and field trips on the Hubbard Brook Experimental Forest and nearby areas. The tentative draft of the problem analysis for the White Mountain area was discussed and watershed calibration procedures for both the Pocono and Mountain State areas were also discussed by the group. We felt that the meeting accomplished a number of objectives by getting together men with similar interests and mutual problems. Both Lou Metz and Ed Johnson made a number of comments and suggestions which were very useful to the Northeastern group. Howard Lull conducted the meeting and summarized the highlights in a brief memo.

During the summer season, 3 weir sites were prepared and a 3/4 mile jeep road built to make them accessible. Construction on one of the weirs is about finished, and we expect to have this watershed operating by the beginning of the dormant season.

Howard Lull spent a week with us in April working on the frost and humus papers and reviewing an early draft of our watershed research problem analysis.

We enjoyed a three-day visit from Sid Weitzman in June. Sid spent some time at Hubbard Brook and made a number of helpful suggestions. We're sorry he sprained his knee and suffered so from insect attacks. It seems that the gentle terrain and benign wildlife in West Virginia are poor preparation for New Hampshire's rugged outdoor environment. We understand now why the Fernow boys were so amazed at Russ Hutnik's stamina when he transferred down there from Laconia.

Ray Lavigne, Frank Cunningham's right-hand man at the Hopkins Forest for the past few years, transferred to us at the end of June. He and his family now live within a couple of miles of the watershed.

Our student assistant this summer was Bill Kerr, a 1956 geology graduate of Massachusetts State University.

Trimble reported seeing a moose track up in the watershed. To add credence to this tale, Sid Weitzman was with him at the time.

COASTAL OAK-PINE RESEARCH CENTER

Si Little, Horace Somes, and Howard Lull, with cooperation of the Geological Survey, Soil Conservation Service and soil surveyors, and Seabrook Farms, started a study in September to determine the effect of water spreading in tree growth, understory composition, and soil characteristics. Two pairs of plots were selected, one affected and one unaffected by water spreading. On the treated plots, water had been applied at the rate of about 600 inches a year for the past 6 years. To date, vegetation has been tallied, soils described and classified, and soil samples taken. The water is applied to these areas through rotating nozzles which thoroughly wet down all vegetation. According to bark characteristics, all oaks in the treated area belong to a new species, Quercus slimiyi.

PUBLICATIONS

Report No. 3. Forest and water research project. Delaware-Lehigh Experimental Forest. Irvin C. Reigner, W. E. McQuilkin, E. F. McNamara, and Howard W. Lull. 44 pp., illus. Harrisburg.

Snow storage and melt in a northern hardwood forest. Richard S. Sartz and George R. Trimble, Jr. Jour. Forestry 54: 499-502.

Manuscripts submitted

Water yields from small forested watersheds. Sidney Weitzman and K. G. Reinhart.

Influence of land use and forest condition on soil freezing and snow depth. Robert S. Pierce, Howard W. Lull, and Herbert C. Storey.

The role of forest humus in watershed management in New England. George W. Trimble, Jr. and Howard W. Lull.

Factors influencing streamflow from two watersheds in northeastern Pennsylvania. Howard W. Lull and Herbert C. Storey.

A program of watershed management research on forest lands in the upper Delaware and Susquehanna river basins. Howard W. Lull and Irvin C. Reigner.

Physical properties of 123 soils in the Northeast. A. R. Eschner, B. Jones, and R. C. Moyle.

PACIFIC NORTHWEST FOREST AND RANGE
EXPERIMENT STATION

Watershed Management Research
Semiannual Progress Report, April 1, 1956 - September 30, 1956

General

Watershed research activities in the Pacific Northwest have stepped up considerably during the past six months. Our program has expanded into the Siskiyou-Cascade Research Center of southwest Oregon, the fourth province in the Pacific Northwest to receive attention. Work in the other three areas is progressing nicely in spite of recruitment difficulties. Essentially, we are still in the planning stage but some specific studies have been started which promise to give early results.

In June Ned Bethlahmy reported for work on the Bull Run Study. Without much delay he became immersed in the problems peculiar to a cooperative project. His major activity this summer has been the selection of test watersheds and installation of a gage.

Siskiyou-Cascade Research Center

Personnel have not yet been recruited for watershed research and we anticipate some delays in filling the position.

In the meantime, Lloyd Hayes, the research center leader has been doing an outstanding job with local groups interested in water problems. In his capacity as technical advisor to the Douglas County Water Resources Committee he has done much to clarify thinking on watershed problems. For three months he acted as chairman of the committee and in addition has been chairman of a recreation subcommittee.

In recent months with Hayes' help the Umpqua Basin Council drafted proposed legislation designed to reduce watershed damage from logging in Oregon. The Council, a subunit of the Oregon Wildlife Federation, depended heavily on Hayes' knowledge of watershed protection requirements in logging and road building operations.

Willamette Research Center

Corvallis Watershed Study

A study of soil changes resulting from logging and slash burning in the Corvallis Watershed has been completed and a manuscript is in preparation for release this fall. This cooperative study was conducted by C. T. Dyrness, graduate student in forest soils, as part of the requirements for the Master of Science degree, Oregon State College. He was assisted by a contribution of funds from the watershed management division.

these, probably in 1957. Hook gages have been installed at the flumes for greater accuracy of measurements. Debris basins have been traversed to measure bed load accumulation, and suspended sediment sampling at the spillways is continuing. Traverse surveys of the watersheds to determine area have started, with one completed to date. Maintenance of the Lookout Creek and Blue River gages is continuing.

Mid-Columbia Research Center

Work thus far has been largely a reconnaissance of the province with thought being given to the types of research projects needed and the locations best suited for each type of research study.

Flood and Mud

Need for studies related to soil stability was emphasized by the occurrence of numerous mud flows and flash floods following two high intensity summer rain storms. The highway between Entiat and Wenatchee was closed by four mud flows in one afternoon. Other mud flows in the Cashmere-Monitor area caused considerable property damage and plugged the irrigation canal and tunnel supplying the famous Wenatchee apple orchards. Two weeks of night and day labor were required before canal service was restored. A reconnaissance of the troublesome watersheds after the storms indicates that while rain storms are acts of God, man can take credit for the mud flows. In all cases, poor land management was a contributing factor to the floods from small watersheds. A working plan for a study of rehabilitation measures on some of these problem areas is being prepared. Surface lysimeters will be used to obtain a quantitative measure of the effect of each rehabilitation treatment.

Another study related to soil erosion in the planning stage is a comparison of the Wyssen Skyline Crane with conventional logging systems. A demonstration Wyssen operation has been underway for two years in the ponderosa pine type of the Okanogan National Forest.

A watershed management research center would be incomplete without experimental watersheds. Some possible sites have been located but, since they do not meet all the specifications, the search continues.

Soil Studies

An important phase of the research at Mid-Columbia is going to center around a soils laboratory. Equipment has been purchased to make many of the standard laboratory determinations of soil properties. In addition an air pycnometer has been custom-built to aid in determination of soil porosity and moisture retantion values. A soil sampler was made which withdraws an undisturbed core to fit the air pycnometer. An apparatus was also designed and constructed to provide for wet-sieve determinations of soil aggregation.

There are no plans for an extensive soil analysis program at this time, but rather an orderly accumulation of knowledge concerning the soil properties associated with major soil types. This information will be of great value in planning the use of wild lands. Surface geology and land form maps prepared by John Arnold of Region 6 will be used as a base and soil properties correlated with his mapped units. It has been possible to develop a soil stability index of twelve classes based on soil parent material and land form. The map and index will be checked in the field this fall.

Blue Mountain Research Center

Cattle Management Study

The first year's sediment deposits in the basins for the study of the effect of grazing intensity on erosion of summer ranges were mapped in September. The data have not been worked up yet, but no spectacular results are expected. Several years' deposit will probably be necessary before any significant differences appear.

Pilot Rock Cooperative Project

Lodgepole pine of the Blue Mountains was subjected to close scrutiny with the assistance of Walter W. Jeffrey, and exchange graduate student from Scotland. Lodgepole covers thousands of acres in the Blue Mountains (we'll have a better figure upon completion of the forest inventory in this area next year). The age of the 50 stands examined shows remarkably little variation, running 60 to 80 years with only few exceptions. Stem size, however, varies from saplings to small sawtimber and appears dependent largely on stand density at time of establishment. Neither lodgepole nor grand fir (Abies grandis) are found on soils other than the fine pumicite which overlays much of the residual basalt clay. The two species are seldom found on south slopes since the pumicite occurs largely on north slopes or flats, having presumably been eroded from south exposures. The concentration of lodgepole on north slopes makes it particularly important from the standpoint of snow management. Lodgepole pine seldom has a crown ratio greater than 30 percent. A surprising amount of light penetrates the canopy of even relatively dense stands. More snow may also reach the ground as compared to the grand fir-Douglas-fir-western larch stands that are typically climax on the pumicite sites.

Examination of areas from which lodgepole pine has been harvested indicates that no serious soil disturbance occurs on flat ground (steep slopes have not been logged as yet). Twenty-five to 35 percent of the surface is covered by slash, which thus far has been left as it lies.

Erosion Control Projects

A serious problem in the Blue Mountains is the extensive area of scab ridges which contribute heavily to flooding of the Umatilla, Grande

Ronde and John Day Rivers. These ridges were completely denuded by over grazing in the 1880's. The vegetation on most of these ridges consists only of cluster tarweed (Madia glomerata), which has no value for forage, soil stabilization or humus accumulation. The soil is a heavy basalt clay, often less than 4 inches deep. The ridges approach the "tin roof" type of watershed, but the thin soil mantle offers some possibility of modification by vegetation establishment. Attempts to seed them to grass failed, however, since the soil is subject to severe frost heaving. In 1952 the research center and the Umatilla National Forest started a study on the use of wood chips combined with nitrogen fertilizer as a heave-preventing mulch. The results showed that 1/2 inch of chips with 150 lbs./acre of nitrogen provided adequate protection for establishment of a satisfactory grass stand. The cost of treatment does not justify it for forage production, but its implications in soil stabilization and increase of infiltration rate and water-holding capacity make it an important watershed management tool. We are giving thought to amplifying these studies.

Terracing road cuts and unstable alpine soils is now underway as an erosion prevention measure on the Wallowa-Whitman National Forest. These will be seeded to grass and their success will be closely followed.

Problem Analysis

A problem analysis of our area continues to occupy a considerable share of our thoughts. After the end of this calendar year we are looking forward to the arrival of another full-time man at the research center. Our watershed studies will be greatly facilitated by the addition.

Visitors

On June 19 the American Society for Range Management, Pacific Northwest Section, held a field trip at Starkey Experimental Forest and Range. Grazing management as related to erosion and runoff was discussed. We have the prospect of a soil survey on the Starkey partly as a result of reconnaissance trip which included Dr. Ellis Knox, Oregon State Soil Survey Coordinator, Dr. C. T. Youngberg of Oregon State College and Bill Anderson, Rudy Mako and Grant Lindsey of the Soil Conservation Service.

Other visitors this summer included Walter L. Schipull and Henry Lobenstein, who inspected proposed erosion prevention measures on subalpine areas near Anthony Lakes of the Wallowa-Whitman National Forest; and Walt Hanson, Walt Lund and E. H. Eyre, who viewed results of using wood chips for grass establishment on scab ridges and discussed possibilities for timber and watershed management in lodgepole pine.

Bull Run Project

Activities on the Bull Run Watershed have followed three main lines:

1. Problems of the area were studied and a decision made as to the one which should be tackled first.

2. Working relations were established with the agencies and personnel concerned with our activities.

3. Field work was pursued with the greatest possible dispatch before the onset of winter.

Program Plans

George Barr (who early in August was recalled to active duty in the Army) did a meritorious job of assembling, from divers sources, information concerning the watershed. Maps, aerial photos and geological reports were assembled and studied to enhance our acquaintance with the area. A decision was then reached that for the remainder of the field season all our efforts would be concentrated on the establishment of precipitation and stream gaging instruments. This course of action was motivated in part by an analysis of the personalities of our cooperators. Field installations, although involving a great deal of effort, are concrete objects which are easily appreciated.

Field Installations

Since late June, field work has consisted of selecting watersheds suited for study within the Bull Run Reserve, building a road to three selected gaging sites, and the installation of a gage on one stream. Because the streams in the area carry a very large amount of debris, a trapezoidal flume of the type developed by Goodell was considered the most feasible. One further accomplishment during the season was the erection of a 15-foot steel tower on which we have installed a storage-type recording rain gage.

A leak developed in the flume after the installation. It was repaired once, developed a second time and repaired once more. We now have our fingers crossed as to future developments. The Bull Run area is located on highly fissured basaltic rock, and the question which has been plaguing us is whether or not we can effectively and permanently seal the bedrock. Discussions with the City Engineer revealed that the same problem confronted the City of Portland after construction of the main city reservoir. In this case, literally thousands of bags of cement were dumped into the reservoir to seal bedrock. In our case, if a leak develops again, we may resort to the use of bentonite, and if that procedure fails, we may have to revise our entire philosophy of stream gaging procedures within the area.

Miscellaneous

For a period of two weeks (August 6-22), Ray Graber, a forestry student at the University of Washington, assisted with the field work.

Bethlahmy discussed the Bull Run Project for the Portland Hydro-Tech club in August.

SEMIANNUAL REPORT -- APRIL 1956 THROUGH SEPTEMBER 1956
Division of Watershed Management Research
Rocky Mountain Forest and Range Experiment Station

The report from the Rocky Mountain Station is intended to convey the straight from the shoulder thoughts of the watershed management researchers here. Contributions are not edited in Fort Collins, but are read with interest and then sent on. I agree with the remarks from the Washington Office that comments and discussions concerning things in the report are desirable, and hope we'll hear from the rest of you.

Barr report

A study of the Salt River watershed in Arizona, sponsored by the University of Arizona, Salt River Valley Water Users' Association, and the Arizona State Land Department has aroused a great deal of interest in the possibilities of watershed management. This investigation has the purpose of making an economic evaluation of the possibilities of increasing water yields by changes in land use. It is under the leadership of Dr. George W. Barr, Head of the Agricultural Economics Department of the University. Hal Wilm, Dudley Love, Buss Croft, and Perc Rowe have served as consultants to Dr. Barr on the question of managing vegetation to increase water yields. The report is expected to be released soon and should help to clarify some of the controversial issues in Arizona.

Sediment

Most of you know that the Sedimentation Subcommittee of the Inter-Agency Committee on Water Resources is sponsoring research on sediment sampling. Hoover is a member of the technical committee for the inter-agency sediment project. Workers on the project are anxious to receive suggestions to aid in working out methods to sample sediment automatically. B. R. Colby, the project leader, has prepared the following summary of present thinking. Your suggestions are awaited.

Automatic Sediment Sampling Program
A Statement by B. R. Colby, U.S. G.S.
St. Anthony Falls Hydraulic Laboratory

Under the direction of the Technical Committee of the Subcommittee on Sedimentation of the Inter-Agency Committee on Water Resources the cooperative project at the St. Anthony Falls Laboratory is attempting to improve the methods of determining sediment loads in streams with primary emphasis on problems of suspended sediment in flashy or intermittent streams. The ultimate objective is to obtain a continuous, automatic record of the sediment concentration or discharge of a stream. The ultimate goal may well lie beyond the scope of talent and instrumentation now available. However, some progress should be possible by a concerted effort to improve methods of obtaining sediment records.

Because of the complexity of the problem involved, the probability that instrumentation may require knowledge in many scientific fields, and the desirability of benefiting from experience in many areas of sedimentation the widest interest and cooperation is solicited. The problem of sediments and sediment transport appear in such fields as mining, abrasives, ceramics, air pollution , sanitation, and even in the flow of blood in the body. Adequate measurements of sediment movement (sediment loads in streams in this instance) is one requisite for an understanding of sediment transport.

At the present time suspended sediment loads in streams are computed from the concentration of sediment in intermittent samples, and the concentration, perhaps adjusted by a coefficient depending on sampling procedures, is combined with streamflow to determine suspended-sediment discharge. Suspended-sediment concentration is determined from the dry weight of sediment in the sample of water-sediment mixture. The quantity of sediment might be determined approximately from the volume occupied by the sediment that settled out of a sample. The available methods of determining suspended-sediment loads are laboricus, costly, and personnel requirements are excessive for satisfactory determinations for streams in remote locations.

The suspended-sediment load of a stream is the mineral solids content of the flow. Suspended sediment travels essentially in suspension and contacts the stream bed at infrequent intervals as distinguished from the bed load which is composed of particles that slide, roll, or skip along the stream bed. Suspended-sediment discharge is the quantity--for our purposes the weight-- of suspended sediment that passes a given point in a stream in unit time; it is also proportional to the product of the velocity averaged concentration of suspended-sediment and streamflow. In this discussion the streamflow will be assumed to be available, so that a determination of sediment concentration will suffice to determine sediment discharge. Any information on the sediment load in addition to the suspended-sediment discharge--for example, data on the size distribution of the sediment--would be welcome but may not be essential.

Determination of sediment content from which to compute sediment discharge may be made on water-sediment mixtures which have any one of three general relations to stream discharge:

1. Determinations may be made in the flowing stream. These require automatic measurement and recording of sediment concentration or sediment discharge at one or more points in the stream.

   A. Indirect methods of sampling are required
   B. Accuracy likely to be low.
   C. Samples or portions of flow need not be diverted from the stream.
   D. Possibilities are good for continuously recording sediment load with a minimum of attention if difficulties of infrequent determinations can be solved.

2. Determinations may be made of the sediment content in a continuously diverted portion of the streamflow.

   A. Diversion of a uniform fraction of the total flow and sediment
      (1) Problems of instrumentation to obtain a uniform fraction of the streamflow and sediment are difficult.
      (2) Concentrations could be recorded in the diverted flow rather than in the main stream.
      (3) Flow would be reduced to more manageable quantities for some types of sediment measurements.
      (4) Diverted flow may be composited into a single sample for long periods of time and analyzed later for total sediment content.
   B. Diversion of a uniform or perhaps a non-uniform quantity of flow and variable proportion of sediment.
      (1) This type of diversion is simpler to obtain than a continuous uniform fraction of the total flow.
      (2) Automatic, continuous determination of concentration would provide a good record of sediment discharge.
      (3) Diverted flow cannot be composited into a single sample for later analysis except for periods of uniform flow.

3. Determinations may be made of the sediment content of intermittent samples of the streamflow.

   A. Samples may be analyzed automatically at the field site.
   B. Samples may be analyzed singly or composited into samples representing periods of time or ranges of discharge.
   C. Quantity of water-sediment mixture can be relatively small for transportation to a laboratory or to simplify analysis.
   D. Samples may be analyzed at a laboratory at a convenient time after sampling.
   E. More office computations may be required than for other methods.

In general, present standard methods of determining sediment concentration are limited to analysis of intermittent samples with some possible application to analysis of a continuous diversion from the stream. Therefore methods of obtaining a sample from a stream for analysis must be investigated for (1) intermittent samples, by automatic pumping (Frigidaire Division of General Motors at Moraine City, Ohio), and by single stage automatic samplers (Austin, Texas,and Lincoln, Nebraska,offices of the U. S. Geological Survey); (2) continuous diversion by orifice, or by pumping; and (3) continuous diversion of a uniform fraction of the total flow (Bradeau, 1951, Barnes and Fevert, 1954).

However, the possibilities for improving sediment measurements will be severely limited unless new methods or refinements of old methods can be developed for automatic determination and recording of the sediment content of water-sediment

mixtures. Methods of separating the sediment from water-sediment mixtures and automatically determing the weight or volume of sediment should be investigated. Best opportunities for rapid progress seem to be by improving indirect methods of determining sediment content.

The following outline has evolved from an attempt to increase the scope of thinking regarding possible developments in indirect methods of determining sediment concentration. The outline presents some of the characteristics of water-sediment mixtures that vary with the sediment content. Comments on the possibilities, the means of measuring the characteristic, instruments that are usable or have been used for the measurements, and other pertinent remarks are given. The outline is far from a complete coverage.

Characteristics of water-sediment mixtures

I. Density
   1. One of the most direct indices of sediment concentration
   2. Direct measurements by
      A. Displacement--hydrometers.
      B. Volume-weight determinations.
   3. Indirect measurements by
      A. Pressure differences between points of known elevation in the fluid mixture .
         (1) Differential manometer (Wahlen type gage--Skidmore, 1948)
         (2) Differential pressure transducer (devised by Hubbard and reported by Appel, 1952).
         (3) Difference between pressures by two bubbler gages (gages used by U. S. Geological Survey) .
      B. Electromagnetic method (Honick, 1954).

II. Viscosity

III. Color
   1. Presumably depends on material composing the sediment and on particle size.
   2. Has a general relation to sediment concentration.
   3. Might be recorded by color photos.

IV. Abrasive qualities
   1. Presumably vary with sediment particle size and stream velocity as well as sediment concentration.
   2. Might be measured by
      A. Rate of erosion of material held in the flow .
      B. Change in electrical potential as a function of removal of aluminum oxide from an aluminum plate.
      C. Color of an easily oxidized metal immersed in the flow.
      D. Acoustic devices

V. Transmission of electric current

1. A function of chemical constituents of the fluid.
2. A function of mineral constituents of the sediment.
3. Resistance may be ohmic for direct current or impedance for high frequency alternating current .
   A. Report by Morgan and Pirson (Tech. Publication No. 2462 of American Institute of Mining and Metallurgical Engineers, Sept. 1948) .
4. Change in wet cell potential because of movement of electrolyte around the cathode (Boyer and Lonsdale, 1953).
5. Current generation by movement of liquid conductor through a magnetic field (Kolin, 1945).

VI. Transmission of light

1. Presumably affected by color and refractive index of minerals in the sediment.
2. Sediment in suspension reduces the amount of light which will penetrate the fluid mixture from a given source.
3. Sediment in suspension increases the amount of light diffused from a beam of light.
4. Both transmitted light and scattered light may be measured.
   A. Turbidimeter (Bradeau, 1952; General Electric).

VII. Transmission of radio-active energy--analyses using isotopes

1. Presumably a function of the mass of sediment in suspension.
2. Sediment in suspension between a source and an indicator of intensity reduces the intensity received--two probe method.
3. Sediment in suspension diffuses radio-active energy so that an intensity indicator will record transmission from a source directly behind a shield of small extent--source and recorder may be placed in a single probe with a lead shield between.

VIII. Transmission of sound

1. Rate of travel of sound waves changes with concentration of sediment in a water-sediment mixture.
2. Supersonic waves--ultra high frequency--act much as light or radio-active energy.
   A. Transmission along a direct path decreases with an increase in sediment (Killen, Univ. of Minnesota, 1954).
   B. Diffusion of supersonic waves is increased by an increase in sediment concentration.

IX. Momentum

1. The specific gravity of sediment particles is greater than one and the sediment particle has a greater momentum than an equivalent volume of water.
2. The water-sediment mixture has a greater density than water alone, therefore a greater momentum at the same velocity.

X. Cooling effect
   1. The heat content and cooling (or heating) effect of the water-sediment mixture varies with the sediment concentration

XI. Reaction to chemicals or other treatment
   1. Presumably varies with volume of sediment in the water-sediment mixture

The preceding outline is intended to stimulate optimistic and positive thinking along possible lines of measuring sediment in water-sediment mixtures. For the present, difficulties of application or lack of necessary information are ignored. Readers with special areas of interest and experience will be able to expand parts of the outline and increase its value. We ask for contributions of ideas, reports of methods and instruments, and suggestions as to sources of information that would further this cooperative effort.

Something new

The September issue of THE ATLANTIC (198:3 pp. 25-26) in a section entitled "Science and Industry" reports on two developments that are of interest.

The Armour Research Foundation has adapted two de-icing chemicals for aircraft use but both may have application in preventing ice and rime on weather instruments. One is lithium chloride which is dispersed in water soluble, flexible polyvinyl alcohol. The composition is cast into tapes and stored in rolls which stick to the wing as easily as ordinary pressure tape. The other chemical is polymerized ethylene glycol which is solid at room temperature. This is melted and sprayed on aircraft and solidifies into a smooth tough film.

The other development illustrates one of the practical ways in which the "water problem" must be solved by using water more efficiently. It is a home sewage system called "Sanitoi" which has been tested at Purdue University. The aerobic activated sludge principle is applied to a one-home waste disposal plant. All waste material is ground up by a mechanism set in each toilet and then pumped to a treatment tank in the cellar or outside. Compressed air is forced through the tank and aerobic bacteria rapidly turn everything into harmless and odorless gas that escapes through a vent. Water is recirculated to the toilets, being pumped over and over again through the system. No new water need be added once the system is put into operation.

If bath and kitchen drains feed into the tank, an overflow pipe and a small drain field must be provided but much less area needed in the field than for an ordinary septic tank. Pumps, grinders, and compressors are electric powered and it is reported that a typical household system sells for $600.

Now if someone will develop a nice green plastic lawn that needs water only when necessary to wash off dust, the "water shortage" will be less troublesome.

Book

A highly recommended book is "Climates in Miniature" by T. Bedford Franklin. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y. 1955. It is extremely readable and should give almost anyone an interest in microclimate and some new ideas.

(M. D. Hoover)

Grand Junction

Black Mesa watershed studies

Stream gages and the pretreatment measurements of watershed conditions are nearly completed on Black Mesa. Three watersheds are being gaged, using 90° V-notch weirs. The watersheds vary in size from about 100 to 300 acres and will be subjected to light, moderate, and heavy grazing by yearling steers. Vegetation, ground cover, and soil porosity will be measured periodically during the study (at least 10 years). Changes in these factors, which are brought about by grazing treatments, will probably be reflected in the sediment production measured at the stream gages and possibly in runoff characteristics. If one or more of the treated watersheds deteriorates during treatment to the point where excessive sediment is produced, we will be able to establish some minimum plant and ground cover requirements for watershed protection. These requirements will be in terms measurable by ordinary range analysis procedures, so they may have considerable application as watershed guides in management of grazing lands of this type.

In addition to the treatment effects we expect to measure, we will be gathering basic hydrologic information on these high-elevation mesa-type watersheds. This will include such factors as precipitation, volume and timing of runoff, and temperature during snowmelt. By combining these findings with those from our concurrent study of water use, we should end up with a fairly complete picture of the hydrologic circle.

To date we haven't been able to decide on the best method for analyzing the effects of treatment. We know that the influences of antecedent soil moisture, winter snow pack, and temperature during snowmelt must be isolated from effects of plant and ground cover. Also, there is the complication that we have no control watershed and calibration must necessarily be limited to 1 or 2 years. Any suggestions?

Water use study

Present plans are to continue the water use study started last year. In this project we are using gravimetric methods to measure soil moisture withdrawal under aspen, spruce-fir, Thurber fescue, Idaho fescue, Gambel oak, and a mixed big sagebrush-weed type. Soil moisture at the end of the growing season is subtracted from that at the beginning of the season to determine the gross amount used. This figure is computed for each foot of soil to a depth of 8 feet. Adjustments are made for precipitation during the growing season.

The preliminary figures on water use during the 1955 growing season were as follows:

Depth (Inches)	Aspen	Spruce	Idaho fescue	Thurber fescue	Oak	Oak herbaceous
0-12	1.69	1.24	1.77	1.67	1.48	0.92
12-24	2.28	1.16	1.91	1.94	2.40	1.42
24-36	2.24	1.13	1.50	2.38	2.07	1.46
36-48	2.73	1.15	.70	1.32	1.06	1.45
48-60	2.61	.90	.67	.52	.27	.93
60-72	2.52	.63	.70	.39	.28	.53
72-84	1.77	.82	.52	.36	.16	.66
84-96	1.10	1.02	.89	.39	.10	.60
Total	16.94	8.05	8.66	8.97	7.82	7.97
Precipitation	4.20	4.20	4.20	4.20	4.30	4.30
Total use	21.14	12.25	12.86	13.17	12.12	12.27

Surface runoff from rainstorms during the growing season was negligible.

The data have not been analyzed statistically yet, but it looks as if aspen is by far the most extravagant water user. If this finding is borne out by further years of measurement, the implications in management of these lands for water production may be considerable.

(Harry Brown)

Tempe

The new phreatophyte program has been concerned largely with the development of an apparatus for the direct measurement of transpiration of intact plants. This apparatus has now been successfully assembled and tested.

Transpiration is measured in terms of milligrams of water vapor per second under controlled light, humidity, temperature, and wind. It is similar to the one used previously for measuring photosynthesis (Plant Physiol. 29: 305-306, 1954) except that the infrared gas analyzer is sensitized to water vapor rather than

carbon dioxide. The effect of light intensity, air temperature, and humidity on transpiration rate of Tamarix pentandra has now been measured. Results were reported at the 1956 annual meeting of the American Society of Plant Physiologists, and a manuscript describing the work has been prepared. The laboratory apparatus is intended to be a pilot model for a field apparatus that is now being constructed. The field model will be an open rather than a closed circuit design. The system will be ventilated at a constant rate and the moisture content of inflowing and outflowing air will be determined. Previous experience indicates that surface absorption of water vapor becomes critical and limiting in the closed circuit model and makes it impractical for field work.

Control of erosion on loose granitic soils after chaparral vegetation has been destroyed by fire is a real need. The results of seeding weeping lovegrass on a chaparral burn near Globe, Arizona, are highly encouraging. To measure vegetational changes, nine 100-foot line transects were located within an enclosure that has been protected from grazing since the fire, and nine transects were located on an adjacent grazed area.

The following tabulation shows grass and shrub density as measured on the line transects in the falls of 1952, 1953, and 1956. Since shrub growth occurs both in early spring and in late summer, the measurements represent results for $1\frac{1}{2}$, $2\frac{1}{2}$, and $5\frac{1}{2}$ growing seasons after the fire.

	Mean vegetation intercept			Percentage change	
	1952	1953	1956	1952-53	1953-56
	Feet per 100-foot transect			(Percent)	
GRASS					
Grazed	0.51	0.77	0.46	+50.98	-40.26
Ungrazed	.72	1.06	1.28	+47.22	+20.75
SHRUBS					
Grazed	23.37	27.86	43.67	+19.21	+56.75
Ungrazed	22.02	24.94	37.05	+13.26	+48.56

These data indicate the following tentative conclusions:

(1) Chaparral shrubs sprout very rapidly the first growing season. Over half of the shrub density measured in 1956 was present in the fall of 1952, $1\frac{1}{2}$ growing seasons after the fire.

(2) Grazing seems to favor an increase in shrub density at the expense of weeping lovegrass density. Between 1953 and 1956 grass density on the grazed area suffered a 40 percent reduction in basal density while grass density on the ungrazed area gained almost 21 percent over that of 1953.

The cooperative watershed study between the Arizona Game and Fish Department, the Salt River Water Users' Association, the Tonto National Forest,and the experimental station in the chaparral zone is now commencing its calibration period. Weirs have been completed on the four experimental watersheds of 50 to 275 acres. Since the weir sites are accessible only by jeep,large concrete blocks (8" x 12" x 16") filled with concrete were used for constructing weir walls instead of poured concrete. These weir walls have not been tested by flood flows, but construction is fast and economical and appears adequate for small watersheds under warm weather conditions. The stilling wells furnished by Salt River Valley Water Users' Association were corrugated metal culvert pipe, with shop cut doors, and a ring welded on the top to hold the instrument shelter house. Field installation consisted of a concrete pad under the stilling well and angle iron braces bolted to concrete pads on the bank. The angle iron braces support the catwalk to the shelter house. Thistype of installation is ideal for inaccessible locations.

To expand the existing Castle Creek watersheds study, another watershed was added. This Campbell-Blue watershed is about 6 sections in size and lies in the mature ponderosa pine forest of northern Arizona adjacent to the two Castle Creek watersheds. This new watershed will serve to measure (1) annual and seasonal water yield, (2) runoff peaks, and (3) sediment transport by streams both before and after logging. Data will be measured by a Villemonte weir sill (Roe and Crowe, U. S. Dept. Agr. SCS Tech. Bul. T-51). The weir was installed in an existing 10 x 12 foot concrete box culvert. Villemonte weir sills may lack the precision of a sharp-crested weir for measuring low flows, but they are easy to install and should be an excellent measuring device to obtain basic runoff data wherever box culverts are available. Weir sill forms were built in the shop and the sills were poured in place.

Post logging treatment on South Fork of Workman Creek has been completed. Trees marked for cutting comprised 24 percent of the basal area of the trees on the watershed. Basal area reduction was brought up to 37 percent by stand improvement practices. These consisted of:

(1) Poisoning dwarf mistletoe infected ponderosa pine in the small infected areas and poisoning the infected trees along an isolation strip around the large areas;

(2) Poisoning hardwoods on the ponderosa pine sites;and

(3) Poisoning fir and hardwoods in the pine-fir transition to favor ponderosa pine. Poisoning with ammate appears effective on ponderosa pine, white and Douglas-fir, and Gambel oak but less effective on New Mexican locust.

(H. G. Reynolds)

Rapid City

The first 6 months of active watershed management research work at Rapid City have been devoted primarily to getting acquainted with the Black Hills area, writing study plans, assembling equipment, and initiating field work on two short-term studies. We have also started collecting and compiling all existing available records of precipitation and streamflow in the Black Hills.

While the two studies which have been initiated are aimed at specific problems in the Black Hills area, it is expected that they and the precipitation-streamflow compilations will provide basic soil and water information needed to set up a more complete and comprehensive research program.

Precipitation and streamflow in the Black Hills

Precipitation in the Black Hills region is of the plains type. It is characterized by abundant rain during spring and summer months, and very light precipitation, mainly snowfall, during late fall and winter months. At Custer, in the Central Hills, 14.48 inches, 79 percent of the total average annual precipitation of 18.33 inches, falls during the months April-September inclusive. An average of only 3.85 inches of precipitation falls during the period from October 1 to the following March 31. June is the maximum month on the average. Minimum months vary with the station from November through February. But more minimums are listed for February than any other month.

Streamflow appears to follow much the same seasonal trend as precipitation. Maximum flows frequently occur during late May or early June coinciding with the period of maximum precipitation. But thereafter streamflow recedes more rapidly than precipitation as the height of the growing season is reached. Winter flows are low and apparently relatively constant.

Considerable snow apparently accumulates during late winter and early spring months in the northern and higher portions of the Black Hills. At Dumont, elevation 6140 feet, average annual snowfall is 105 inches with the greatest amounts falling in January and March. Melting of the accumulated snow pack therefore yields considerable streamflow, particularly in the larger drainages that head at the higher elevations. Rapidly melting snow coupled with spring rains have also been reported to have generated several highly destructive floods in several drainages.

These generalizations are drawn from existing records of Black Hills precipitation and streamflow. There are records of varying length for climatic and stream-gaging stations scattered throughout the Hills. Assembled under one cover they should be valuable for reference use, provide a better understanding of local precipitation-streamflow relationships, and show where additional records may be needed. Such an assembly and analysis of data is planned for completion and publication within the next 6 months.

Bulk density and pore space of soils as related to grazing

The Kentucky bluegrass type is very common in stream bottoms, particularly in the central and northern Black Hills. Since the type is highly favored cattle range, it has received long and highly concentrated grazing use.

It has been reported that peak summer storm discharge rates have increased over the years at the expense of stable seepage streamflow. Soil compaction by livestock trampling in grassed streambottoms is held at least partly to blame, the theory being that it has compacted the soil and reduced its permeability. If this is the case it should be reflected in the pore space and bulk density of surface soils. This is the basis for one of the field studies which was initiated during the last 6 months.

Soil core samples of 250 cc. volume have been collected in and outside four livestock exclosures. These exclosures have records of grazing protection varying from 5 to 16 years. Samples were collected by 2-inch depth intervals from the soil surface to 12 inches. A total of 434 samples have been collected and analyzed for pore space drained by 60 cm. water tension and for bulk density.

Analysis of data has only just been started. However, data from outside the first exclosure were analyzed to determine variability in bulk density and large pore space. This was done to aid in determining intensity of sampling necessary to achieve a 10 percent sampling error at the 95 percent confidence level inside the exclosure and at the other exclosures. Samples were collected from the 0-2, 2-4, and 4-6 inch depth intervals at 10 random points. Expecting less variation in bulk density and large pore space at greater depth the 6-8, 8-10, and 10-12 inch depth intervals were sampled at only 5 points.

Soil at the first sampled exclosure is a silt loam and of alluvial origin throughout the surface 12 inches. There was a dense mat of roots and a large amount of organic matter in the surface 2 inches. Roots decreased in abundance with increasing depth.

Means and percent sampling errors for large pore space and bulk density are summarized by 2-inch depth intervals in the following table:

	Depth interval (inches)					
	0-2	2-4	4-6	6-8	8-10	10-12
Bulk density						
Mean	0.99	1.12	1.03	1.02	1.05	1.08
Percent sampling error	2.8	1.8	1.7	2.6	1.8	2.0
Large pore space						
Mean	11.6	8.4	11.6	13.3	13.4	13.2
Percent sampling error	10.3	10.5	8.7	13.9	11.7	14.7
No. of samples	10	10	10	5	5	5

Bulk density was lowest in the 0-2 inch layer and highest from 2-4 inches. Values for the other depth intervals were intermediate. Sampling error was greatest for the 0-2 inch layer because of more variation in abundance of roots, amount of organic matter, and greater difficulty of sampling. However, the error is still relatively small. According to calculations, only three samples would be needed to achieve a 10 percent sampling error at the 95 percent confidence level.

Large pore space was least in the 2-4 inch depth interval which also had the highest bulk density. There was slightly more large pore space in the 0-2 and 4-6 inch depth intervals than in the 2-4 inch layer. The greatest amount of large pore space occurred in the three depth intervals below 6 inches. Sampling error for large pore space determination was much greater than for bulk density. According to calculations, about 40 samples would be needed from each 2-inch depth interval to achieve a 10 percent sampling error at the 95 percent confidence level.

Many of the samples showed a fine platy structure, but it was particularly evident in the 2-4 inch depth interval. This feature plus the relatively high bulk density and small amount of pore space suggest that the 2-4 inch depth interval may be in a compacted condition. However, final conclusions will have to await the comparison of results from inside and outside the exclosures.

Soil moisture under thinned and unthinned pine

There are extensive areas of immature second-growth ponderosa pine in the Black Hills. Many stands ranging from sapling to pole size are so dense that tree growth is extremely slow and little or no game or livestock forage is produced. There has been local speculation that these stands consume excessive amounts of water and have caused a general decline in streamflow.

These are the facts which led to the inception of a soil moisture study under thinned and unthinned pine. The object of this preliminary study is to determine whether or not there are measurable differences in soil moisture depletion under the two conditions.

The study as planned calls for direct gravimetric sampling for soil moisture. This requires deep soil with few rocks. A continuing search is underway for the necessary combination of timber stand and soil conditions. The study will be established as soon as a suitable area is located.

(Howard Orr)

Fort Collins Research Center

Fraser Experimental Forest

A study into the effects of harvesting mature lodgepole pine on the water equivalent of the snow pack was started on the Fraser Experimental Forest in 1938. Pretreatment measurements of the snow

pack were made for 2 years. Logging was done in the winter of 1939 and 1940. Post-treatment measurements were made in the 3 following years.

The results, published in U. S. Department of Agriculture Technical Bulletin 968, showed that significant increases in the winter snow accumulation were caused by the reduction in timber density. The original timber volume was 11,900 board feet per acre. The cutting was designed to test the effects of reducing the volume to each of the following values: 6,000, 4,000, 2,000, and 0 board feet per acre. Measurements made during the 3 years after logging showed the following relative values of water equivalent in the snow pack before the start of spring melt: 100, 119, 129, 143, and 144 when the value for the uncut stand is taken to be 100.

There has been no further cutting on the plots since 1940, but some mortality has taken place, mainly from windthrow, and there has been abundant regeneration which, by 1956, had reached an average height of about 5 feet.

In early spring of 1956 a resurvey was made of the snow on plots uncut, on plots cut to 4,000 board feet per acre, and on plots clear-cut of all merchantable timber. The results showed no significant changes over those observed in the first 3 years following logging. The plots cut to 4,000 board feet per acre had, in 1956, 128 percent of the snow contained on the uncut plots, and the clear-cut plots had 139 percent of that on the uncut plots. Apparently, the regeneration, after 16 seasons of growth, is still not of sufficiant size to affect materially snow interception and evaporation.

Wind speed and direction have been observed on the Fraser Experimental Forest for several years for three reasons: (1) To help characterize the climate; (2) to help relate snow evaporation to the causative factors; and (3) to identify wind damage to the forest with the causative winds.

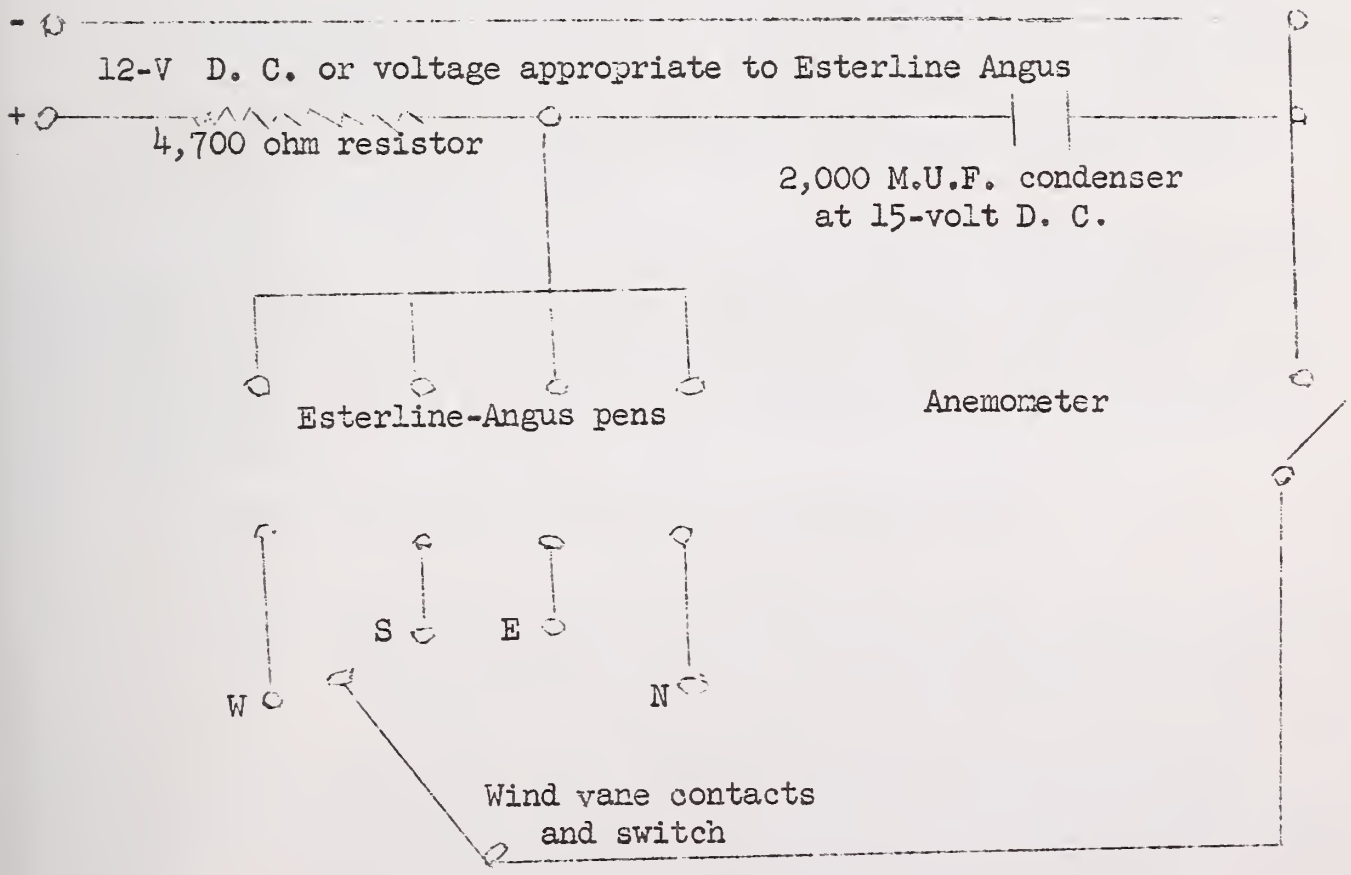
For these observations, an anemometer and Bendix-Friez wind vane with electrical contact box have been connected to an Esterline-Angus operations recorder. One pen has recorded wind speed, four other pens have registered wind direction. To save battery drain, a rather complex electrical circuit has been used between the sensing instruments and the recorder. The circuit, originally developed by the Navy Electronics Laboratory, effectively reduced battery drain so that, instead of requiring two fresh storage batteries per week, eight type-A dry cells lasted for a year or more.

However, the use of separate pens for wind speed and direction made difficult the compilation of data. Wind speed could be read easily, but could not be readily identified with direction in a manner suitable to the summarizing of speed and direction in the form of wind roses. Also, the circuit responsible for registering of wind direction was complicated by a vacuum tube of limited life and gave considerable trouble.

These difficulties were overcome by connecting the anemometer and wind vane in series and using a simplified form of the electrical circuit, thus maintaining the advantage of low battery drain. Only four pens are used for the recording of wind speed from each of eight directions. The compilation consists of tallying pips on the chart according to each of eight categories representing eight wind directions.

The complete circuit employed is shown below. Each pen responds individually to only one wind direction. However, the contacts on the wind vane are such that if the wind direction is intermediate between two cardinal directions, two pens will operate. Thus, if the wind direction is southwest, both the south and west pens are activated. This is a feature of the vane itself and no creation of this author.

Currently, at another site a $22.50 wind vane, sold by M. C. Stewart of Ashburnham, Massachusetts, is being used in place of the vane sold by Bendix-Friez costing several times as much. In an identical circuit it is working equally well.



Anemometer and Wind Vane Circuit

(B. C. Goodell)

Alpine snowfield study

Density, ablation, and aerial shrinkage were measured at snowfields located at four sites east of the Continental Divide in the Front Range of Colorado during the summer of 1955. Wind, temperature, precipitation, and humidity were also recorded at each site. Aerial photographs of a part of the Front Range were examined to determine the number and size of alpine snowfields that persisted through the summer.

Snow density was found to exceed 0.80 during most of August at three of the fields. Later work has shown these densities taken with the Mt. Rose snow sampler to be too high. Probably a better estimate for these densities would be 0.70. Ablation varied from 3.3 feet per week during late August on a southern exposure to 1.1 feet per week in mid-September on a northern exposure. It averaged about 2 feet per week for the 2½ months following July 1. Ablation released about 13 acre-feet of water during July and August for each acre of snow existing on August 1. This amounted to about 0.2 acre-feet of water per day per acre of snow. Calculations using Light's equation indicated that 95 percent of this was available for streamflow under the weather conditions that prevailed. Thirty-five percent of the July and August streamflow in one drainage was attributed to melt water from the alpine snowfields. A proposal was made to increase the effect of alpine snowfields on streamflow by the construction of barriers to drift additional snow and to regulate melt by applying dirt or other material to the snow surface.

During the summer of 1956, preliminary studies were carried out to determine the effect of covering portions of snowfields with a carbon black dirt, rocks, and sawdust, on snowmelt. In the latter part of July, marked wands were placed in the experimental plots to determine the changes in the depth of snow. The plots were 3.3 feet x 3.3 feet in size.

The treatments consisted of the following:

(a) A control with no treatments.
(b) The application of 2½ pounds of carbon black to the plot.
(c) The application of dirt screened through a 1/2-inch hardware cloth so that it covered the snowfield to a depth of 2 to 2½ inches.
(d) The application of a thin layer of dirt so that it covered the snow to a depth of 1/2 inch or less.
(e) The application of rocks 3/4 inch to 1 inch in diameter in a single layer over the snow.
(f) The application of fresh sawdust so that it formed a layer 2 to 3 inches thick over the snow surface.

The following tabulation shows the result of these treatments on snowmelt for the period July 28 to August 16:

Treatment	Average melt (feet)
Check	5.82
Carbon black	6.32
Thick dirt	3.98
Thin dirt	6.05
Rock	5.95
Sawdust	2.77

The least significant difference is 2.76 feet of melt. Only the plots covered with sawdust significantly retarded snowmelt. The carbon black, thin dirt, and rocks tended to speed up snowmelt, but not significantly.

(M. Martinelli)

FS History Office
Reference Shelf

PIEDMONT RESEARCH CENTER

April - June 1956

Climatic Summary

The month of April was excessively wet, having 2.01 inches of precipitation over the 50-year average for the month.

Both May and June were dry months; the rainfall for May and June was .91 and .75 inch below normal, respectively.

For the first six months of the year, the total amount of precipitation is 2.20 inches in excess of the 50-year average.

Quarterly Climatic Summary - Calhoun Experimental Forest

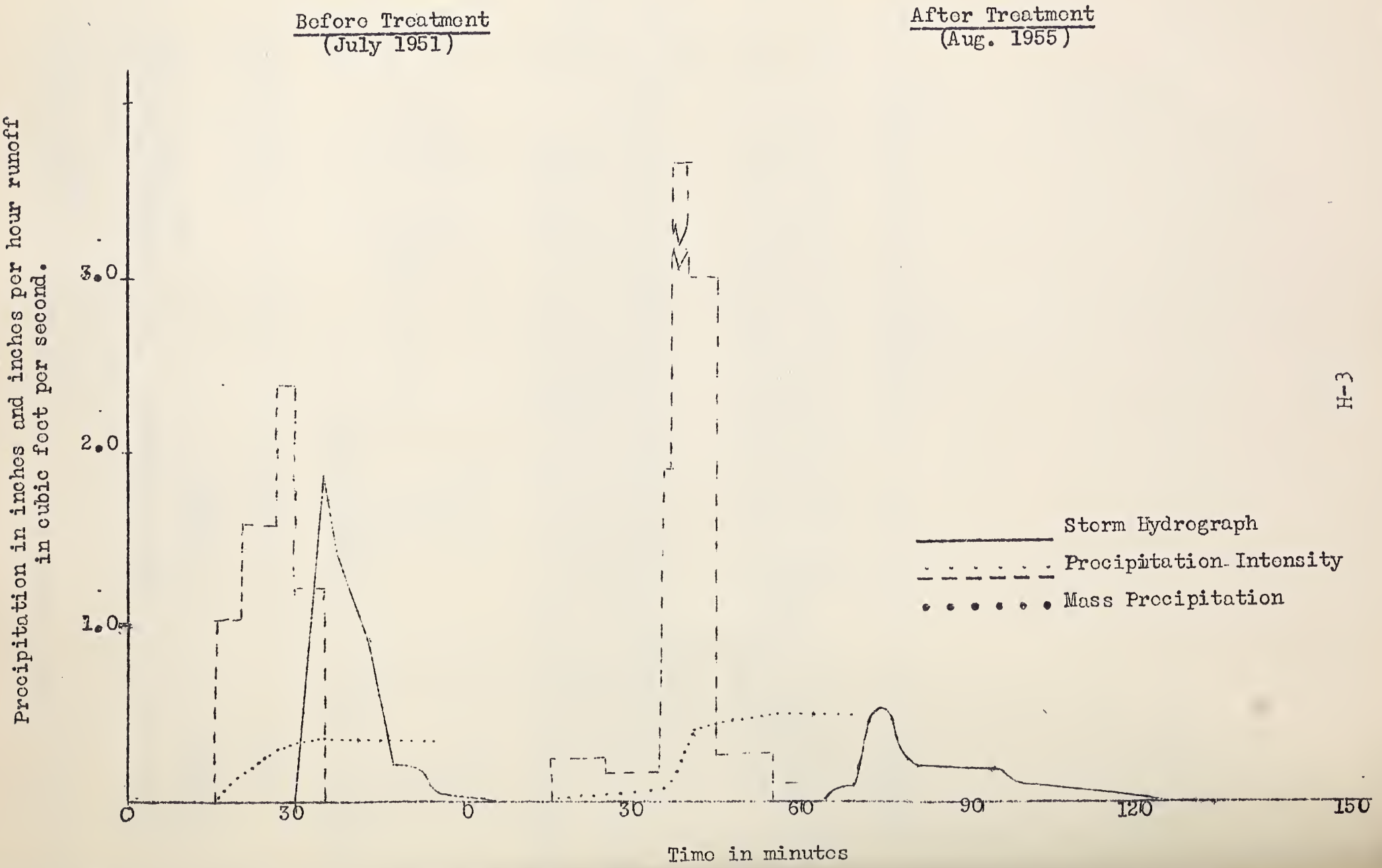
Month	Average temperatures			Highest temp.	Lowest temp.	No. of days with rain	Precip.	Evap.
	Max.	Min.	Mean					
	°F	°F	°F	°F	°F		Inches	Inches
April	72	44	58	85	25	7	5.48	5.40
May	82	56	69	94	36	6	2.45	5.58
June	90	62	76	100	49	4	3.06	5.99

Watershed #1

Work was begun on the analysis of the streamflow records on watershed 1. This area contains approximately 15 acres of which four acres were badly eroded. The upper slopes of the watershed support a 15-year-old plantation of loblolly pine, and the lower drainages support a pine-hardwood stand. In mid-April 1955, the gullied area was smoothed with a bulldozer, fertilized, mulched and seeded to lespedeza and crotalaria. Small check dams were constructed along drainages to prevent the disturbed soil from eroding severely during summer storms. The treatment was completed by the end of May 1955 (see SEFES Annual Report for 1955, page 47, for before and after treatment pictures).

The effects of the treated gullied area were immediately noticeable in the streamflow records. Figure 1 shows the effect of the treatment when before and after treatment storms are compared.

Figure 1.-A comparison of two storms at Watershed 1, Calhoun Exp. Forest, before and after treatment.



The following is a comparison of the storm and soil characteristics of the two periods compared in the figure.

Total soil moisture in 0 - 66" zone	Before treatment	After treatment
	Inches	Inches
Pine plantation	21.61	22.01
Gullied area	24.18	22.31

Storm	Before treatment	After treatment
Total rainfall (inches)	.45	.51
Max. 10-minute intensity (in./hr.)	1.68	1.92
Peak discharge (cfs.)	1.89	.51
Volume of runoff (cu.ft.)	122.15	62.38

Generally speaking, all antecedent conditions and storm characteristics for the Aug. 3, 1955 storm (after treatment) were favorable for greater runoff than for the July 19, 1951 storm (before treatment). Differences in runoff characteristics can be attributed to the treatment on the 4-acre gullied area. It is obvious from Figure 1 that the treatment given the 4-acre gully has reduced both the peak discharge and volume of discharge by more than 50 percent.

The time of concentration of the peak flow was increased from 20 to 54 minutes and the time of runoff from the peak discharge to the end of the runoff was increased from 30 to 77 minutes by the treatment. This reduction in peak flow and rate of flow of runoff by the treatment reduced greatly the rate at which soil was being eroded from the watershed.

Lack of summer type storms of greater magnitude since the treatment prevents a comparison for larger storms.

Hardwood Soil-Site Study

Analyses made in connection with a hardwood soil-site study in the Piedmont show that there is an appreciable difference in soil properties between the various sites sampled. Table 1 gives the maximum and minimum values of 5 soil properties computed for the first 15 plots. These values, except for horizon thickness, were computed from tension table data obtained from undisturbed core samples.

Table 1.--Soil properties of some Piedmont upland hardwood stands

Soil horizon	Horizon thickness	Bulk density	Total porosity	Retention pore space	Detention store space
	(inches)	(gm/cc)	(% by vol.)	(% by vol.)	(% by vol.)
A_1	0.2-7.0	0.84-1.23	53.5-68.3	28.0-43.1	19.6-37.1
A_2	2.1-6.0	0.97-1.53	42.1-63.4	29.6-42.3	11.1-29.7
A_3-B_1	2.2-6.6	1.18-1.54	41.7-55.3	28.3-44.2	7.2-19.4
B_2	--	1.23-1.59	40.0-53.3	30.6-45.9	6.4-14.2

The porosity values of table 1 become more meaningful when they can be visualized as inches of water in a six-inch layer of soil. Table 2 makes such a comparison.

Table 2.--Inches of water in a six-inch layer of soil

Soil horizon	Total water	Retention water	Detention water
	Inches	Inches	Inches
A_1	3.2-4.1	1.7-2.6	1.2-2.2
A_2	2.5-3.8	1.8-2.5	0.7-1.8
A_3-B_1	2.5-3.3	1.7-2.7	0.4-1.2
B_2	2.4-3.2	1.8-2.8	0.4-0.9

Effect of Burning on Forest Soil

A study was started ten years ago in the Coastal Plain by personnel of the Santee Research Center concerned mainly with testing the use of winter or summer fires in the control of understory hardwoods in immature stands of loblolly pine. Some plots have been burned annually; others less frequently.

Aside from the influence of the fire on the understory hardwoods, and current growth rate of the pine, there is a question as to its accumulative effect on soil properties. The burning tests are on a very flat area, so no erosion has been noticed. However, the burning could so alter soil properties that over a long period the site might be changed enough to influence future tree growth.

In cooperation with the Santee Research Center, a rather complete set of measurements will be taken on the burned and control plots. A preliminary test was made on two plots and the data for these are given below.

The first measurements were confined to one check plot and one other plot which has received nine annual summer fires (an extreme treatment). Thirty random sampling points were selected on each of the two quarter-acre plots and undisturbed samples were collected of the 0-2" soil layer and a small bag sample of loose soil was taken from the same depth.

The organic matter content averaged 14.21% on the burned plot, and on the unburned plot 18.89%. Because the quantity of organic matter was so great, the determinations were made in a muffle furnace rather than by chemical methods. The 4.68% difference is significant at the 5% level. Expressed as weight of organic matter in the surface 2" of soil over an acre the burned plot has 67,000 pounds and the unburned plot 71,100 pounds. Since the organic matter content is so high on both areas, the difference is probably not too important from a nutrient standpoint. However, it should be remembered that organic matter influences many other soil properties.

The bulk density indicates the compaction, or total porosity of the soil, and is significantly different for the two areas at the 1% level. The burned area has a bulk density of 1.04 and the unburned area 0.82. These values show that the surface 2" of soil in the burned area is more compacted than in the unburned area. Translated into porosity values the bulk densities show that the burned area has 60.7% total pore space and the unburned area 69.1%.

The mean percolation rate for the unburned plot is 14" per hour and that for the burned is 10" per hour. However, the variation within each plot is so great that no significant difference is evident.

The data given above show that there is a distinct difference in the soil properties of the two areas sampled. The information collected so far will be used in designing the sampling and analytical procedures used on the other plots in the study.

Southeastern Forest Experiment Station
QUARTERLY PROGRESS REPORT

DIVISION OF WATERSHED MANAGEMENT RESEARCH
COWEETA HYDROLOGIC LABORATORY

April - September 1956

General

A major change in technical personnel at Coweeta occurred during this period. The transferees were Ed Johnson to Central States as Chief of Division of Watershed Management, Jake Kovner to Rocky Mountain as Station Statistician, and Ken Pitcher to Asheville to follow his interest in statistics. The replacements were Don Whelan from Region 7 for Ed, John Hewlett from Syracuse for Jake, and Pete Black from Michigan for Ken. The new staff will do their best to carry on the outstanding work of the former staff and their predecessors.

Preliminary Soil Survey of Coweeta

Arrangements were made with the State Soil Survey Coordinator for the Western District in North Carolina to map the soil series of Coweeta Hydrologic Laboratory. A reconnaissance was made to determine the number of soil series which would be mapped on the unit watersheds. SCS had several men here for a week classifying the soils and checking the 1942 survey map. Soils series identified on the Coweeta area are shown on Table 1. This information will be used to establish the hydrologic differences between soils and between watersheds.

A Utah soil sampler was borrowed from the Piedmont Research Center to obtain a monolith display of samples for these soil series. We are finding these monoliths very helpful in focusing attention on the soils aspect of our research program and in providing guides for setting up new studies.

Studies

Watershed 22 was treated again with silvicides to put 50% of the area in a deadened condition. The area was originally treated in alternate strips 1/2 chain wide after the strips have been cruised 100%. This study is the first step in establishing the relation between water yield and stand density for watersheds having a cover varying from 0 to 100%.

Watershed 1 is now being cleared and partially burned to the extent necessary in preparation for planting white pine in the spring of 1957. The water yield of Watershed 1 (south facing) can then be compared to that of Watershed 17 (north facing), which was planted to white pine in the spring of 1956.

Table 1.--Soil series identified on Coweeta watersheds

Order	Great soil group	Series	Texture	Parent material
Zonal	Red-yellow podzolic	Hayesville	clay	granite, gneiss, or schist
		Clifton	clay	hornblende, gneiss and schist
		Fannin	clay loam	mica schist or mica gneiss
		Rabun	clay loam	hornblende, gneiss and schist
		Tate	loam	colluvium
	Gray-brown podzolic	Halewood	light clay	granite, gneiss, or schist
		Porters	loam	granite, gneiss, or schist
		Ashe	fine sandy loam	granite, gneiss, or schist
		Balfour	light clay loam	granite, gneiss, or schist
		Tusquitee	heavy loam	colluvium
		Watauga	clay loam	mica schist
Intrazonal	Brown forest	Burton	light clay loam	granite, gneiss, or schist
Azonal	Lithosol	Talledaga	silt	mica schist or mica gneiss
		Chandler	stony loam	mica schist or mica gneiss
	Alluvial soil	Congaree	fine sandy loam	recent alluvium

An index network of five soil moisture stations under mountain hardwood stands has been set up to sample a range of conditions by elevations on Coweeta. The initial work is being done by Dave Striffler of Michigan as a Master's thesis. This study will be helpful in our water balance work and for orienting future soil moisture studies.

An interception study is being started by Pete Black on Watershed 100, Barker's Cove, which is also to be done as a Master's thesis under the University of Michigan. This study will run for one year in order to obtain interception data during both the growing and dormant seasons. A special feature of this study will be the use of standard rain gages for measuring thrufall rather than the troughs. There are several reasons for this change. The number of possible positions for the interception troughs are limited unless the supports are specially constructed. Since it is the plan to change completely the random location of the rain gage troughs every three months, this objection is particularly applicable. The regular interception troughs are subject to inaccuracies due to splashing and to change in area by denting. The rain gage troughs can be read directly, while the values from the interception troughs must be converted to inches of rainfall. We would appreciate comment on this feature.

A special study will be made to test the existing precipitation network for adequacy. The network was primarily designed for measuring the rainfall on the total area. The main emphasis will be on strengthening the values for unit watersheds.

Hydrologic Notes

Climate

Our temperature for the second and third quarters were below normal with only one month, May, being above normal.

Table 2.--Climatic Summary of Air Temperature and Evaporation - WS-1

	Temperature						Evaporation	
	Average		Maximum		Minimum			
	1956	Dev. from normal	1956	Dev. from normal	1956	Dev. from normal	1956	Dev. from normal
April	52.6	-3.2	67.0	-1.6	38.2	-2.8	3.70	-.06
May	63.3	+2.2	76.7	+0.9	49.9	+3.3	3.74	-.36
June	66.4	-2.4	80.2	-1.9	52.5	-3.1	4.27	+.24
Average	60.8	-1.1	74.6	-0.9	46.9	-0.9	3.90	-.06
July	70.6	-0.5	83.0	-0.4	58.2	-0.5	4.16	.00
August	70.6	0.0	84.9	+2.0	56.4	-1.8	3.90	-.14
September	62.9	-2.2	76.8	-2.0	49.0	-2.4	3.19	-.01
Average	68.0	-0.9	81.6	-0.1	54.5	-1.6	3.75	-.05

Precipitation

While the precipitation for the calendar year has been slightly above normal, the general precipitation deficit which started June 1955 has not been satisfied.

Table 3.--Precipitation summary

	Total	Deviation from Normal
April	9.34	+3.42
May	4.08	-0.33
June	5.10	+0.49
Total	18.52	+3.58
Water yr. to 6/30	47.06	-1.83
Cal. yr. to 6/30	40.77	+3.75
July	6.86	+0.34
August	2.55	-3.19
September	4.86	+0.55
Total	14.27	-2.29
Water yr. to 9/30	61.33	-4.43
Cal. yr. to 9/30	55.04	+1.56

Cooperation

Region 7

Johnson and Shope spent June 5 thru 8, 1956, on the George Washington with Supervisor Anderson and his men reviewing in the field the provisional road layout on the pilot type demonstration studies on Black Run and Dunkle Hollow proposed timber sales. A recording rain gage and water quality station were set up at key points on each watershed. The logging methods and road layout used will be designed to hold the watershed damage to a minimum.

Region 8

A similar study is underway on the Tallulah District of the Chattahoochee. Whelan and Shope looked over the work being done on the Stamp Creek timber sale on August 31, 1956, and reported that the results are excellent to date.

Municipal Watershed

A group of eight men responsible for the operation of the Sylva North Carolina, municipal water supply watershed came to Coweeta on August 9, 1956. They are proposing to log the watershed for saw timber and pulp wood, but do not want erosion to occur that will force them to install a water treatment plant. We discussed with them all the factors involved and showed them the work we are doing in integrated watershed management on Watersheds 40 and 41.

Information and Education

A five-day training session in water resource management was held for twenty-seven foresters from the Mississippi National Forests and Flood Prevention Project.

Three one-day training sessions were provided for 85 students from the Universities of Tennessee, Syracuse, and North Carolina State.

Visitors

The visitor load for the last six months has been somewhat light due to major road construction between Franklin, North Carolina, and Clayton, Georgia. Thirty-two groups, totaling 398, were shown around the Laboratory.

PIEDMONT RESEARCH CENTER

July - September, 1956

Climatic Summary

The months of July and August were very dry. The precipitation departures from the 50-year average were -3.30 inches in July and -4.79 inches in August.

Precipitation for the month of September was 3.89 inches above normal. Hurricane Flossy brought 5.72 inches of rain in five days, 4.13 inches of which fell in one 24-hour period. This storm was of long duration and low intensity.

The water from Flossy penetrated to a depth of 66 inches beneath forested stands and old fields. The soil at the lower depths did not reach field capacity. On barren soil the water from this storm penetrated but 15 inches.

Quarterly climatic summary - Calhoun Experimental Forest

	Average temperatures			Highest temp.	Lowest temp.	No. of days with rain	Precip.	Evap.
	Max	Min.	Mean					
	°F	°F	°F	°F	°F		Inches	Inches
July	93	66	78	104	56	9	1.88	5.40
August	93	65	78	103	52	8	1.00	5.58
September	81	57	74	96	41	8	7.33	5.99

Soil Moisture Publication

Analysis of soil moisture data is complete and a rough draft of the publication "Soil moisture as affected by different types of plant cover" has been written. Total soil moisture was determined by fiberglas blocks distributed through the soil to depths of 66 inches on seven plots. These plots are located in barren areas, a broomsedge field, pine plantations, a shortleaf pine stand, and a pine-hardwood stand.

In general, the results of the study show that recharge and depletion of soil moisture are similar for forest vegetation to depths of 66 inches. On the broomsedge field, soil moisture losses occurred to depths of 42 inches, but losses below 30 inches were negligible. Moisture losses from the barren plot occurred through 66 inches and are attributable to evaporation, vapor movement, capillary movement, and downward drainage.

Figure 1 shows soil moisture depletion by zones for a theoretical 40-day drying period during the summer months. In all zones water is lost most rapidly under the pine plantation and least rapidly from the barren plot.

In the pine plantation soil moisture depletion from the surface 15 inches is initially quite rapid. As moisture in this zone becomes limiting, the rate of loss decreases. Loss after the 20th day proceeds very slowly, indicating that the soil is near wilting. Wilting point determinations show the soil to be slightly below wilting at 20 days.

The soils studied exhibit differences in the amount of water they are capable of holding. The soil of the broomsedge plot holds a greater amount of water than the soil of the plantation. This soil also contains a greater amount of available water than that under the pine plantation. In determining the stresses exhibited by vegetative types, it is necessary to evaluate the shape of the curves and not the volume of water; however, both the amount of available water and the rate at which this moisture is used are important from a growth standpoint.

In the 15 to 30-inch zone, the rate of water loss is less than the rate of loss from the surface 15 inches for all plots. Rate of water loss is lowest from the barren plot.

In the 30 to 66-inch zone, the effect of depth of rooting becomes more apparent. Loss from the plantation progresses at a steady rate for 40 days, indicating that the roots are steadily depleting water from this zone. Roots extend below 66 inches and at no time during this 40-day drying period does the soil moisture approach the wilting point. In the broomsedge plot, water loss continues to be depleted by the few roots present. As shown by the curve, depletion occurs rapidly in the vicinity of the roots and decreases as that water becomes limiting.

The entire soil profile of the barren plot is clay, and loss of water occurs throughout the profile. Moisture losses in the 30 to 66-inch zone are probably due more to downward drainage, capillary movement, and vapor movement than to evaporation; however, evaporation occurs to considerable depths in this soil due to shrinkage cracks which occur in dry weather.

Figure 1.-Soil Moisture depletion by zones under a pine plantation, broomsedge field, and barren area

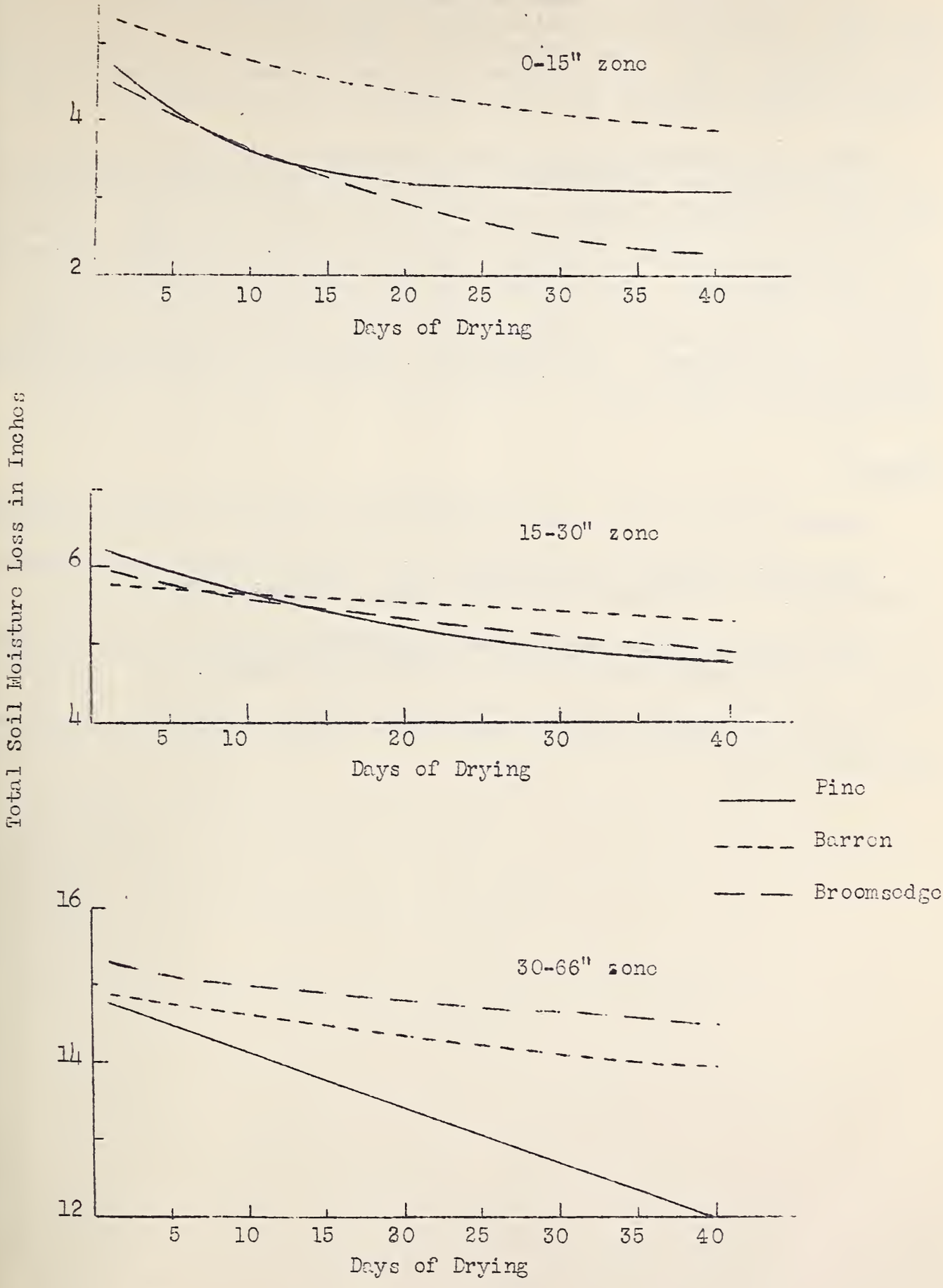


Figure 2 is used to illustrate the effect of depth of rooting on water depletion. Notice that the soil moisture depletion curves for the 0-6 and 6-10 inch zones of the pine plantation are identical and can be superimposed on one another. This indicates that the depth of roots and number of roots is great enough to deplete the 6-10 inch zone as rapidly as the 0-6 inch zone.

Under the broomsedge cover, this relationship does not hold. The roots of the broomsedge are concentrated in the surface five inches and deplete that zone of moisture quickly. In the 5-10 inch zone, there are fewer roots to deplete the moisture. Depletion takes place slowly at first. As water in the surface five inches becomes limiting, the water necessary must come from some other zone. In this case, the most readily available water is contained in the 5-10 inch zone, and the rate of depletion of this zone increases. When the water of the 5-10 inch zone becomes limiting, the depletion rate decreases. This phenomenon, though not so pronounced, is also apparent in the barren plot. In both plots it is evident to a depth of 30 inches.

General

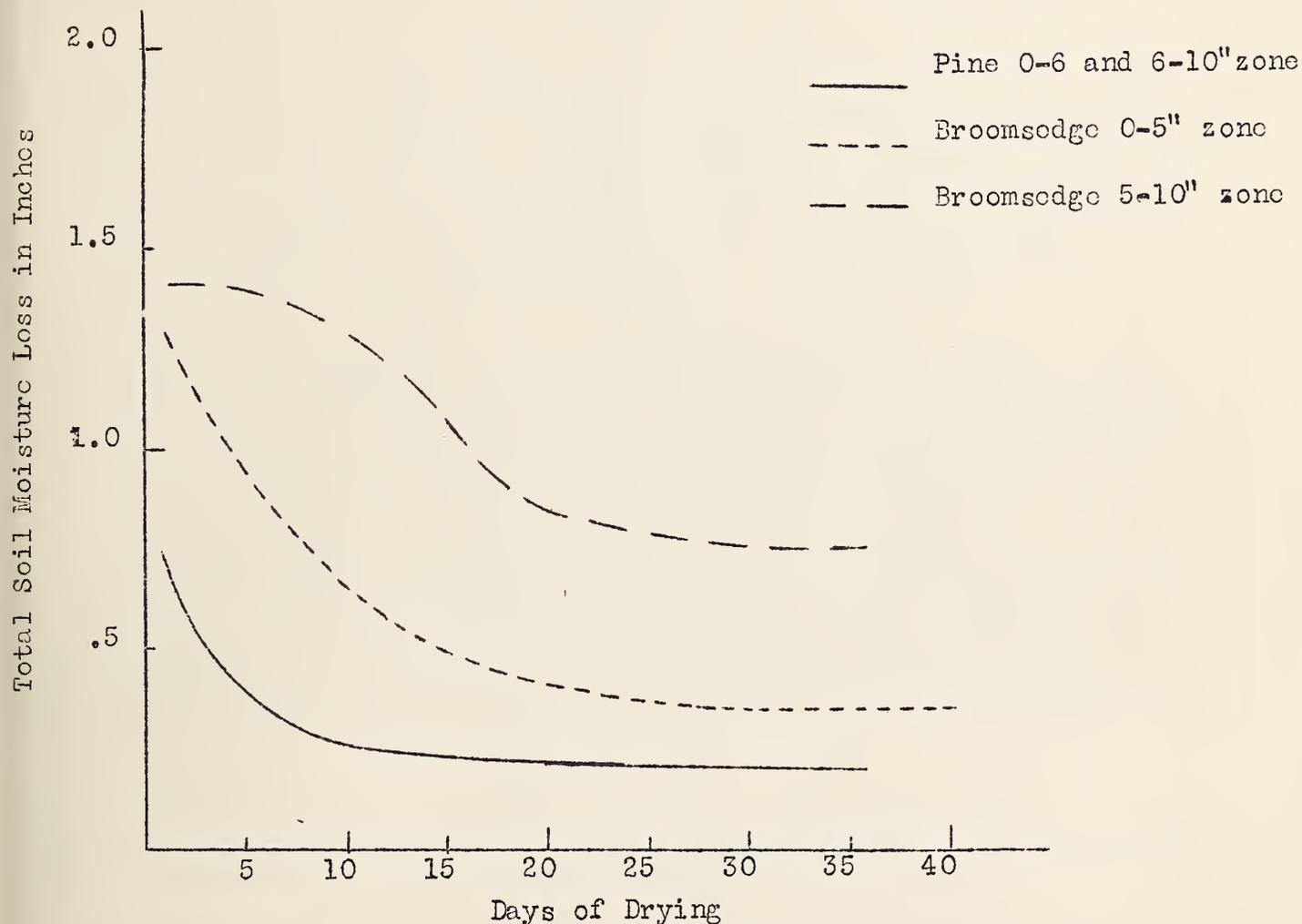
Douglass attended the Junior Professional meeting at Atlanta, Georgia.

The annual program conference for the Piedmont Research Center was held on September 25. Meginnis, Doolittle, Roth, and Zak attended.

The Center is now submitting soil temperature data to the U. S. Weather Bureau for publication in the S. C. Climatological Report.

Dr. J. D. Ovington, Nature Conservancy, London, visited the Center on September 13-14.

Figure 2.-Soil moisture depletion of the surface ten inches of soil under pine and broomsedge cover



SEMI-ANNUAL REPORT
Division of Watershed Management Research
Southern Forest Experiment Station

April 1956 - September 1956

General

The South is rapidly becoming aware of its water problems. Foresters share in this concern, both as managers of forest watershed lands, and as users of water for industrial purposes. Pulpmill capacity in Southern Station territory will be increased about 40 percent when announced expansions and new mills have been completed. Water for other industries, for domestic use, and for irrigation agriculture, is in steadily increasing demand.

Attention is now turning to the forested watersheds whence comes much of the usuable water. The Gulf States Section, Society of American Foresters, has set up a committee to study the impacts of increasing water needs on the forests of the Gulf States. George Stephenson, of the East Texas Research Center, is the Texas representative.

A meeting was held at College Station, Texas, September 18 - 19 on "Water for Texas." Koshi presented a paper on "Water Relations of Trees." The Louisiana Forestry Association, at its Annual Meeting in Alexandria on September 14, held a panel discussion on "Water Management and Conflicting Interests," with participation by southern experts on water resources and uses. Papers given at these and other similar water meetings will be available later.

On April 17, Campbell, Horton, Williston, McClurkin, Smith, and Ursic attended the annual planning conference of the Yazoo Watershed Sedimentation Project held at State College, Mississippi.

Campbell, Williston, Smith, and Ursic also attended a conference with FS, SCS, ARS, and USGS people to discuss the collection of basic data for use in design and evaluation of flood prevention works of improvement on the Yazoo-Little Tallahatchie River Watersheds. This meeting, chairmanned by W. L. Heard, Deputy State Conservationist, was held in New Albany, Mississippi, on May 8 - 9, 1956.

Major developments in the Station program were the assignment of a forester hydrologist to the expanded Central Ozarks-Ouachita Research Center, in north Arkansas, and the proposal to continue cooperation with the Waterways Experiment Station in Mississippi.

Personnel

Jerome S. Horton transferred from the Vicksburg Infiltration Project late in August to the phreatophyte project of the Rocky Mountain Station at Tempe, Arizona.

Robert A. Tobiaski has been designated as acting officer in charge of VIP. He and Edmond I. Swensen returned to Vicksburg from Puerto Rico in June.

Dr. James L. Smith transferred from the Tallahatchie Research Center at Oxford, Mississippi, to the Central Ozarks-Ouachita Research Center in late August. His headquarters are at Hot Springs, Arkansas.

John L. Thames transferred from the Vicksburg Infiltration Project to the Tallahatchie Research Center in late August.

Robert E. Taylor transferred from the Vicksburg Infiltration Project to the Willamette National Forest in Region 6 in June.

Publications

Manuscripts Published

Carlson, C. A., Reinhart, K. G., and Horton, J. S. Predicting Soil Moisture in the Surface Foot of Soil. Soil Science Society of America Proceedings, Vol. 20, No. 3, July 1956.

Doss, B. D., and Broadfoot, W. M. Properties of 91 Southern Soil Series. Southern Forest Experiment Station Occasional Paper 147, 15 pp. 1956.

Manuscripts Being Edited

Taylor, R. E. Some Properties of 144 Soils in Three Intermountain States. Intermountain Forest and Range Experiment Station.

Thames, J. L., and Swensen, E. I. Properties of 160 Soils in Four North Central States. Lake States Forest Experiment Station.

Eschner, A. R., Jones, B. O., and Moyle, R. C. Physical Properties of 134 Soils in Six Northeastern States. Northeastern Forest Experiment Station.

The above three papers will be published by the respective Experiment Stations similar to the Southern Station's O.P. 147, "Properties of 91 Southern Soil Series," by Doss and Broadfoot.

Progress Report 4 is in the printed draft form and is being edited for final printing by the Waterways Experiment Station. The Report

summarizes the site characteristics, soil properties, and prediction relations of all sites for which the Project has obtained detailed soil-moisture and climatic records.

Manuscripts in Preparation

Carlson, Charles A. Estimation of the Field Maximum Moisture Content. (To be presented at the November 1956 meeting of the Soil Science Society of America).

Thames, J. L. Measurement of Soil Moisture over Extended Areas from a Single Installation of Fiberglas Electrical Resistance Units.

McClurkin, D. C. Tree Radial Growth in Relation to Soil Moisture Content.

Vicksburg Infiltration Project

Consultants Meeting

The Vicksburg Infiltration Project came to a definite turning point with the Consultants' Meeting of July 31 - August 1. At this meeting, history of the Project was reviewed and a tentative method presented for the prediction of soil-moisture content. The general conclusion was that soil moisture can be predicted with reasonable accuracy in well-drained soils throughout the United States. It is probable, however that refinements can be made to increase this accuracy. Plans were presented for possible future work to make the prediction method more widely applicable in trafficability forecasting. Following the meeting, the Corps of Engineers made a request that the Forest Service continue its work, concentrating on refinements of the method and on extension to wet soil conditions.

Consultants present at the conference were:

Mr. Herbert C. Storey	U. S. Forest Service, Washington, D. C.
Mr. Marvin D. Hoover	" Ft. Collins, Colo.
Dr. Howard W. Lull	" Upper Darby, Pa.
Dr. Robert S. Campbell	" New Orleans, La.
Mr. Philip A. Briegleb	" New Orleans, La.
Mr. Walter S. Hopkins	" Berkeley, Calif.
Mr. C. E. Molineaux	Air Force, Cambridge, Mass.
Dr. Irving W. Burr	Purdue University, Lafayette, Ind.
Mr. G. W. Musgrave	Soil Conservation Service, Washington, D. C.
Dr. H. G. Wilm	State University of New York, Syracuse, N. Y.
Dr. A. A. Warlam	Consulting Engineer, New York, N. Y.
Mr. A. C. Orvedal	Soil Conservation Service, Beltsville, Md.
Mr. R. R. Philippe	Office, Chief of Engineers, Washington, D. C.

Since its start in 1951 the Project has studied soil moisture-climatic records collected at frequent intervals, usually daily, from 131 sites located in 17 states and Alaska. From these data, soil wetting and drying relations and other pertinent relationships were developed for each site. These results have now been printed in draft form as Waterways Experiment Station Technical Memorandum 3-331, Report No. 4, "Forecasting Trafficability of Soils, Information needed for predicting moisture in the surface foot of various soils."

From these data a set of tentative standard relations were developed for soil-moisture prediction at sites where detailed records of soil moisture were not available but where soil and site characteristics were known. These standard relations were developed for application at the sites studied in the soil strength moisture-surveys reported previously in previous Semi-annual reports. The surveys were conducted in 1954 and 1955 in four regions: Southern, Northeastern, Lake States, and Intermountain. Site descriptions and soils data were collected from over 600 sites, each of which were visited 8 times during the one year period. Standard relations were used to predict soil moisture for the period of the study for comparison with the actual soil moisture. 601 sites were used in these comparisons; some sites were destroyed in farming operations and some were eliminated because of such miscellaneous reasons as continuous flooding, obvious errors in bulk density, etc.

The deviation of the predicted soil-moisture content from the actual soil moisture by using the standard relations is shown in the following table by survey regions.

Region	No. of Sites	Average deviations in inches of water 0-6-in. depth	6-12-in. depth
Southern	178	0.28	0.28
Northeast	122	0.37	0.37
Lake States	160	0.38	0.33
Intermountain	141	0.32	0.28
All sites	601	0.33	0.31

It was found that prediction was less accurate for sites which were kept moist by a high water table. Separation of sites by a wetness index (a site with Index of 1 was very dry throughout the year, and one with an Index of 4 had a water table in the surface foot of soil for a part of the year) gave the results shown in the following table:

Wetness Index	No. of Sites	Average deviations in inches of water 0-6-in. layer	6-12-in. layer
1	91	0.22	0.20
2	291	0.31	0.29
3	112	0.35	0.33
4	107	0.45	0.43

Deviations for the wet sites are obviously much higher than for the drier sites.

Relation of texture upon the deviations of predicted from actual are shown in the next table:

	0-6 in. depth		6-12 in. depth	
Texture	No. of Sites	Average deviations in inches of water	No. of Sites	Average deviations in inches of water
Coarse	260	0.30	247	0.30
Silt	127	0.30	105	0.29
Fine	214	0.39	249	0.33

There is comparatively little difference in success of prediction between these textural groups. However, the prediction of soil moisture content in the clay soils (fine) is somewhat less accurate than in the silts and sands (coarse).

The average deviation of predicted from actual for the Survey sites (slightly less than .30 inches for well-drained soils) was based upon rainfall figures collected from five miles away to very close to the site. Some of the discrepancy was probably, therefore, due to variations in rainfall as well as to deviations caused by use of standard prediction relations. To test the application of the standard relations to sites where more detailed and accurate records were available, the relations were applied to a cross section of the original prediction sites. The deviations obtained by using standard relations are compared in the following table to the deviations obtained by using prediction relations derived specifically for the individual site. Deviations for the survey sites are also included for a comparison.

	No. of Sites	Average deviation of predicted from actual soil-moisture 0-6 inch depth inches	6-12 inch depth inches
Prediction sites			
Specific site relations	30	0.12	0.09
Standard average relations	30	0.25	0.22
Survey sites			
Standard average relations	601	0.33	0.31

Predictions using the standard relations for the sites with exact rainfall records are better than those for the survey sites for which more distant rain gage records were used. However, at the prediction sites the average deviation using the standard average relations are twice as large as those using the specific relations derived for each site.

Statistical Studies

Correlation analyses were continued at the Statistical Laboratory at Purdue University. The purpose of these studies is to relate the expressions of accretion and depletion derived for specific sites to such factors as soil properties, topography, climate, and vegetation which characterize the site, in order to explain the differences in prediction relations between sites and to be able to estimate relations for sites having different combinations of site characteristics. Dr. Irving W. Burr is now supervising these statistical analyses.

Preliminary analyses have been made for accretion and depletion relations, and for the field maximum and minimum moisture contents. The results for the accretion regression analyses, using the slopes and intercepts by single accretion classes and six inch soil layers, showed that the site factors individually or in combination do not appreciably explain the variation of accretion relations between sites. A single set of accretion relations applicable to all sites is indicated from these analyses.

Depletion variation between sites, considering moisture losses from the summer curves during a 20 day interval starting from the field maximum moisture content, is partially explained by differences among 18 site factors. The coefficient of determination, R^2, was 0.50. Of the five variables which account for most of the variation, four help characterize the climate, namely summer temperature, summer rainfall, elevation, and latitude. The need for adjustments of the standard depletion relations depending upon the climate and location of the site is indicated.

Variations in the field maximum and field minimum moisture contents were appreciably explained by variations of the factors; the R^2 values were 0.78 and 0.63 respectively. The possibility of being able to estimate the field maximum and field minimum moisture contents is good.

Tropical Extension

The basic field work for the Tropical Extension in Puerto Rico has been completed and the field crew returned to Vicksburg. Data analysis is in progress. The report is scheduled for completion by the end of December of this year.

Daily soil moisture readings were discontinued on June 15 but weekly readings are still being obtained and calibration samples are being taken once each month by Jose Marrero of the Tropical Research Center. This phase of the study is to continue through another year. The data will be used to check the prediction method developed during the first year.

Future Plans

The tentative future plans for the Project include a comprehensive study of moisture conditions and other soil properties of soil subject to wetting between field capacity and saturation. Moisture measurement under these conditions will be critically evaluated. Studies will be made in the laboratory on natural cores equilibrated at low soil-moisture tension in the field at sites subject to water table influences, and also at field sites during thaw periods.

Tallahatchie Research Center

General.--On July 3, McClurkin, Smith, and Ursic visited Ames Plantation, a 20,000-acre tract in southwest Tennessee maintained in cooperation with the University of Tennessee, to explore possibilities for cooperative watershed management studies.

Watershed Studies.--The project working plan, "Rates of Runoff and Erosion from Major Soil-cover Complexes in the Midsouth," was approved in April. A good part of the summer was spent locating sites for the first of the small watersheds to be used in this study.

Lack of suitable experimental areas on National Forest or other Federal lands hampered initial progress. Finally two sets of three watersheds were located on private land and an easement was obtained.

One battery of three watersheds, each approximately two acres in size, will determine initial rates of runoff and soil loss from abandoned old-fields. Another battery of three two-acre watersheds will be installed on depleted upland hardwood cover. All six of the installations will be on predominantly the same soil series.

After suitable calibration is completed, these watersheds will be used to determine changes in surface runoff and sediment production resulting from various treatments.

Surface runoff will be measured with H type flumes developed by the Soil Conservation Service. Soil loss will be obtained with a fractional wheel sampler installed below the flume. Plans for the flume were located and invitations for bids let in September. Plans for the concrete approach section are about completed.

The sedimentation section of the ARS, recently moved to the University of Mississippi campus, is planning to install similar watershed installations on cultivated and pasture lands.

All this work is being done in cooperation with the Yazoo-Little Tallahatchie Flood Prevention Project which needs basic data on runoff and sedimentation to better plan, design and evaluate the Flood Prevention Program in north Mississippi.

Degree of Root Pruning.--A study to compare early survival and height growth of loblolly pine seedlings pruned to four different root lengths and unpruned seedlings planted by two methods was established in February 1956. Seedlings were outplanted in three randomized blocks on sandy, eroded sites. Although differences were small, seedlings with roots pruned to 10 inches had the best survival in early June. First year survival and growth measurements will be made in October.

Mulch Requirements for Pine Establishment.--A cooperative study to compare the effects of mulch on initial survival and early development of loblolly pine planted on three adverse site conditions was installed in February 1956. Treatments included two rates and two methods of application. Survival was generally good in early June with no apparent differences due to treatment. First year measurements will be made in October.

Morphological Grades of Loblolly Pine.--A cooperative study to compare initial survival and early field performance of three morphological grades of loblolly pine planted on eroded, droughty sites was established in February 1956. While survival was excellent for all three grades in early June, the superior growth and vigor of grade one seedlings was readily apparent. First year survival and growth measurements will be made in October.

Post Hole Plantings as an Aid in Revegetating Eroded Lands.--A study to determine the effect of six methods of site preparation upon survival and growth of loblolly seedlings planted on eroded, exposed coastal plains subsoil was installed during January and February 1956. Four of the methods are designed to test the effect of planting seedlings in top soil filled holes 6 inches in diameter and 24 inches deep in combination with various mulching and fertilizer treatments. The other two methods are designed as controls. They are mattock planting in combination with spot mulching around the seedlings and mattock planting, no other treatment. Height measurements and survival counts schedules for 1956 will be made in October to compare the success of different treatments during the first growing season. The study will extend over a five-year period.

Soil Collection Trench Use in Revegetating Eroded Land.--This study will determine the effect upon survival and growth of loblolly pine seedlings planted on severely eroded sites in trenches which have been allowed to fill with local alluvium. Trenches are expected to fill and be ready for planting during the 1956-1957 season.

Species Adaptability in Adverse Sites.--Virginia, sand, races of loblolly, and races of shortleaf pine which have demonstrated drought resistance in other areas will be tested on adverse sites in the Tallahatchie Area. Seed for each of the species and races were collected and planted in the nursery in 1956 in preparation for outplanting during the 1956-1957 planting season. There were heavy initial losses of seedlings among all of the species to be tested attributed to damping off. Installation of this study may have to be postponed until the 1957-1958 season, pending a new survival count at the nursery.

Grasses and Legumes for Erosion Control.-- A study to determine the effects of selected grasses and legumes on soil hydrologic properties was established in January 1955. Reinforcement plantings were made in the fall of 1955 and the spring of 1956. 5-10-5 fertilizer was broadcast at 100 lbs/acre and a light mulch was applied. Initial germination appeared promising. In mid-year another application of 5-10-5 fertilizer was broadcast at 100 lbs/acre. In November of 1956 the plots will be remeasured to determine the relative success of the different species and any changes in soil physical properties.

Soil Moisture and Tree Growth.--A cooperative study was installed in north Mississippi in April 1954. Final measurements were completed in August 1955. The study was intended to determine the relationships between tree growth and soil moisture content as it varies from day to day and season to season.

Site Changes with Species Conversion.--A study was installed in north Mississippi in March 1954 to determine the nature, rate, and extent of site changes that accompany conversion of blackjack-post oak ridges to pine. Growth and survival continue to be good. This fall the plots will be examined to determine whatever changes have occurred thus far in soil properties.

Soil Moisture Variations with Ridge Conversion.--This study is designed to determine the variations in soil moisture content on blackjack-post oak ridges when the ridges are converted to pine with different intensities of hardwood removal. Soil samples representing the first foot of soil were taken on all plots and were processed in the laboratory. Periodic moisture measurements also were taken on all plots during the growing season. Physical property measurements of the second, third, and fourth foot will be determined this winter.

East Texas Research Center

Effects of Prescribed Burning on Soil-Water Relations of East Texas Forest Soils.--This paired plot study, installed late in 1952, was calibrated 15 months before half the plots were burned in February, 1954. Continuous records of rainfall and soil and water loss, plus triweekly readings of soil moisture at 10 depths are being taken. A major part of the computational work has been kept up currently, and partial analyses of the soil moisture records have been prepared by the Vicksburg Office. Plots are to be burned again during the winter of 1956-57, and analysis of the first four years record is scheduled for 1957.

Effects of Prescribed Burning on the Vegetation and Watershed Values of Rolling Upland Shortleaf-Loblolly Pine Sites.--Final office report on this cooperative study was submitted by Ferguson in June 1956. Results of the 18-month record of rainfall, runoff and soil mositure were rather inconclusive because the runoff plots were not calibrated before burning. There was no evidence that the single fires of the test increased either runoff or soil loss. Soil loss was less than one ton per acre for the 18-month period on all plots.

A Journal of Forestry note covering both silvicultural and hydrologic results is being prepared.

Exploratory Studies on Survival of Pine Seedlings.--During the severe drought of 1954, this study revealed marked differences in seedling survival and soil moisture related to removal of competing vegetation.

Results are to be presented by Ferguson to the Silviculture section of the Society of American Foresters at its Memphis meeting.

Exploratory Study of Micro-climatic Influences on Seedling Survival.--
This study installed by Koshi in the spring of 1956 aims to evaluate the separate effects of shade and mulch on soil moisture, temperature, evapotranspiration and seedling survival. Instrumentation includes Colman fiberglas units, thermocouples, atmometers, and dew point apparatus, in addition to standard recording weather instruments. Despite a hot dry season which has killed over 90 percent of seedlings planted in the grass competition of an adjacent field, no drought losses have occurred on the study plots where competing vegetation has been eliminated.

Central Ozarks Research Center

The Ouachita Mountain area offers a challenge unique to the eastern United States in both the study and application of watershed management techniques. Unlike the other mountain areas of the eastern portion of the country, the greater portion of the area is in either public or large private ownership. Practically all of the critical mountain ridges are in public ownership. Thus, any watershed management techniques found to be beneficial can be utilized upon most critical areas, and upon the greater portion of the entire area.

Physically, the Ouachita Mountains are composed of Paleozoic rocks laid down in a trough. These rocks became strongly folded and formed the Ouachita Mountains. These eastward ridges in many respects resemble the newer Appalachians in structure. They are flanked by the valley of the Arkansas River to the north and the Ouachita River to the south. The belt of folded mountains between these two synclines is an anticlinorium involving Cambrian, Ordovician, Silurian and Devonian beds. The Ouachitas and the folded Appalachians resemble each other in the character of the folding and faulting to which they were subjected, as well as the types of sediment from which the mountains were formed. In both cases, the mountains were formed by a thrusting from the old continental area, now on the ocean side, toward the stable central region, which was formerly covered by the sea. Climatically, the Appalachian and the Ouachita Mountains are quite different. Precipitation in the former is quite high, while that for the Ouachitas averages from 40 to 50 inches per year.

Unlike the Appalachians, the soil mantle covering the Ouachitas is not so highly erodible. However, due to the thin nature of the overlying soil on most ridges, even the loss of one to a few inches to erosion spells the difference between producing or not producing timber crops, and at the same time providing a measure of hydrologic protection to the site. As a result of the broken, faulted nature of the rock, infiltrated water passes quickly through large segments of the ridges to appear as quick return flow in the streams. Water remaining in the shallow soil layer is quickly utilized by vegetation to such an extent that lack of appreciable precipitation for even short periods of one

to two weeks causes droughts over large segments of the mountains. As a result of the seemingly high rate of runoff (surface and return flow), streams are flashy -- running water being present during rainy seasons and dry the rest of the year. This rapid loss of water, together with the relatively low rate of precipitation, vitally affects not only timber growth, but the availability of water for recreational and industrial purposes.

The Arkansas Water Study Commission estimates industry is now using 114 million gallons of water daily in Arkansas. This use is expected to increase to 496 million gallons daily by 1965. Of the amount now used, 70 percent comes from ground water, with only 30 percent coming from surface sources. A large portion of the expected increase must come from this largely untapped surface source. If the Ouachitas are to furnish their share of surface water for the expected increase, it is imperative that timber managers have a clear picture of the results of the manipulation of the timber resources at their disposal, since approximately 80 percent of the entire mountain area is forested. Almost all of the critical mountain ridges and upper slopes are in timber and most of this is in public ownership.

At this stage it would appear the important research needs in watershed management for the Ouachitas are:

1. The establishment of hydrologic factors for representative watersheds in the area, such as infiltration indices, runoff concentration, travel time, channel gains and/or losses. These figures will be needed for later planning and design of water use and control programs and structures.

2. The effects of various timber management practices upon the hydrology of the area, including the effects of such factors as stand structure, timber stand improvement upon available soil moisture, and the effect of fire and engineering changes such as log road construction and skid trails upon erosion and stream flow.